THE JOURNAL OF ENGINEERING EDUCATION

Published by the Society for the Promotion of Engineering Education

Published under the Supervision of the Publication Committee.
R. A. Seaton, H. S. Evans, F. L. Bishop, Editor, University of Pittsburgh.
Published at Prince and Lemon Sts., Lancaster, Pa.

Entered as second-class matter at the Post Office at Lancaster, Pa., under the Act of March 3, 1870.

New Series
Vol. XXIII, No. 8. APRIL, 1933 Subscription Price, $3.00 per year. Single Copies, 50 cents.

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EDITORIALS

The 1933 Meeting.—The 1933 meeting will be the 40th anniversary meeting of the Society and will be held at the Stevens Hotel, Chicago, Ill., June 26–30, 1933. Armour Institute of Technology will be host to the Society on this occasion.

The Society was organized in Chicago on August 4, 1893, at the meeting of the Engineering Congress during the World's Columbian Exposition. It is quite fitting that we should celebrate our fortieth anniversary in the same city and at the Century of Progress Exposition. In order that you may know who is planning to attend this meeting, we shall publish a list of names and addresses of those who notify the Secretary that they expect to be in attendance. If you or some of your associates are planning to attend, please advise us as soon as possible.

We have sent to each engineering school in the United States and Canada placards announcing the meeting. We were pleased, upon request, to send twenty-five of these placards to the Western Electric Company in Chicago.

The sessions will be held on Tuesday, Thursday and Friday mornings, the afternoons being left free for conferences or visits to the Exposition. Wednesday, as you know, will be Engineers' Day at the Exposition and no meeting of any society is scheduled for that day. In the evening there will be a banquet.

The annual dinner of this Society will be held at the Stevens Hotel on Thursday evening, June 27. At this dinner the Lamme medal will be awarded to the person selected by the Committee on Award. The Society will also honor the charter members who organized the Society in 1893 and who made it possible for us to secure the benefits of membership in it.

New Members.—The work of the Society is being constantly recognized by the teaching profession as indicated by the 124 applications for membership received this year. Due to adverse conditions in many institutions we have been asked to remove from the rolls of the Society a number of members this year who have expressed their intention of rejoining when financial conditions have changed.

Sections and Branches.—More meetings of sections and branches have been held this year than in any previous year. The Northwest Pacific Section and the Southwest Pacific Section, authorized at the Corvallis meeting, have perfected their organizations, as has the Colorado-Wyoming Section.

The officers of the Society are exceedingly pleased with the work of the sections and branches. It is with pleasure they note the number who attend these different meetings, the excellent papers which are presented, and the interest displayed in the work of the Society.

METHODS OF TEACHING ECONOMICS OF ENGINEERING *

By EUGENE L. GRANT

Associate Professor of Civil Engineering, Stanford University

The subject of Economics of Engineering is relatively new in the engineering curriculum. Perhaps all of us would agree as to the importance of teaching this subject to all engineering students; certainly, however, we would not agree as to its content or manner of presentation. It is even doubtful if we could agree on any restrictive definition of the phrase, "economics of engineering."

Because teaching in this field has developed independently in so many different institutions, subject-matter and methods of teaching are perhaps farther from being standardized than in almost any other field of engineering instruction. Because of this, it seems to me that any discussion of the teaching problems of this field must grow largely from the individual experience of the speaker. I have therefore no apology to make for the fact that my remarks will relate largely to my personal experience.

My discussion will be confined to the introductory course in this field. My experience with such an introductory course has been, for the last twelve years and in two institutions, to teach a three-hour-a-week course for one quarter, required of all engineering students and taken usually at the end of the junior year.

Change is inevitable in this field of teaching. My own ideas on content and methods of presentation have never been the same two years in succession. Nevertheless, my objectives, I think, have been fairly constant even though they were not so clearly defined in the first years of my teaching.

My idea is that the primary purpose of a course in this field ought to be to give the student a point of view—the point of view that every engineering problem must be considered in the light of its commercial implications. If the student is allowed to graduate in engineering without having been exposed to this point of view, it seems to me that his instruction has been seriously deficient. Engineering problems, before they are finally solved, must nearly always be expressed in money terms.

* A lecture delivered at the Economics Session of the S. P. E. E. Summer School for Engineering Teachers, Stevens Institute of Technology, July 8, 1932.

The central problem of a course of this character should be how to answer the question: "Will it pay?"

This holds true partly because this question really is the dominant factor in so many business situations in which the engineer plays a part—in public works as well as in private enterprises. Moreover, it is true because the engineering student and, in many cases, the practicing engineer are not able to handle the financial calculations involved in answering the question "Will it pay?" I think that many engineering teachers in the past have assumed that since these financial calculations are fundamentally simple, all it was necessary to do was to give the matter brief mention. Perhaps some of you here may have that idea, although the chances are that if you had that idea, you would not be here. However, if you do have it, I recommend this experiment: Set up a simple problem involving a comparison of two machines or structures with different first costs, operating costs, and estimated lives, and give it to a group of students who have had no instruction in this field. I should be greatly surprised if you did not receive some astonishing answers to the simple problem. In fact, I venture to suggest that you might even have a similar experience if you gave the problem to a group of practicing engineers.

It is no more reasonable to say that the time of engineering students should not be spent on the financial calculations incident to answering the question "Will it pay?" because the ideas involved are so simple, than it is to say that engineering students ought not to take time to study statics because the ideas involved in this very important and fundamental subject are so simple. It is certainly true that the fundamental ideas of statics may be very briefly stated. All that is necessary is to apply simple trigonometry and algebra to the rules that the sum of the components of the forces along any axis equals zero, and that the sum of the moments about any axis equals zero; but if you turned loose your students in advanced courses in structural theory with this fragment of instruction, you would soon get into difficulties.

Therefore I say that the question "Will it pay?" may well be made the central problem of the course in economics of engineering, because the engineer needs to know how to answer it, and because he can learn how to answer it much better with the assistance of a little organized instruction. But in addition, "Will it pay?" makes a good central question for this course because it makes the student think about dollars and calculate in dollars, in a wide variety of situations. It gives him more effectively than any other possible presentation the point of view which will make him look for the commercial considerations in different engineering situations. After all, the economics of engineering is more a state of mind than

a body of knowledge. It is more effective, in getting across the desired point of view, to make the student actually work problems involving dollars than it is to give him any amount of reading and conversation about business principles and methods which is not tied down to specific cases. In this connection we may well recognize the tendency of engineering students to learn much more effectively through problem-solving than through conversation.

It seems to me that, in an introductory course in the economics of engineering such as I have had the opportunity to teach, it is practically possible to accomplish two objectives and not much more. First, it is possible to give the student a systematic training in the financial calculations involved in answering the question, "Will it pay?" Second, the student's curiosity may be stimulated regarding all the business matters incident to collecting the data and making the final decisions on the "Will it pay?" question; for example, such matters as business organization and corporation finance, public utilities, government finance, accounting, valuation, cost estimating, and report writing.

If we agree on the purpose of the introductory course in the economics of engineering and on its central problem, there are still many problems of presentation on which we will disagree. On many of these, my own ideas seem to be subject to frequent changes. However, there are certain matters of content and presentation on which I have very definite convictions. I am willing to lay down two specifications regarding this course; then I shall discuss briefly a number of questions which must be answered in developing a course in this field.

My first specification is that great care should be taken to keep the student from getting a too mechanical view of the subject, even though it is possible to present the required financial calculations as a consistently logical set of abstract principles. There is no phase of engineering teaching in which it is more important to avoid what Professor Ennis has called the "deceptive rigor characteristic of engineering instruction." Practical decisions on the economic aspects of engineering situations require so much judgment that more than ordinary care must be taken to counteract the student's tendency to want a definite answer to everything.

This specification may be applied in different ways. For instance, slide-rule work should be acceptable in most calculations. Compound interest tables used ought not to be carried to many significant figures. Formulas for maximum economy, a legitimate subject for advanced study, ought to have only passing mention in an elementary course. Principles should be developed largely through illustrative cases and problems. Although assigned problems may be solved mechanically by the student, there should be

class discussion regarding them which brings in the practical business considerations likely to influence actual decisions.

My second specification for an introductory course in the economics of engineering is that the emphasis should be on general principles rather than on actual cost data or any elaborate study of the facts of particular situations. In these days of rapidly changing prices, the futility of trying to make a student familiar with actual costs in any field is fairly obvious. In stating that emphasis should not be placed on the facts of actual problems in economics of engineering—for example, such a thing as the economics of power plant design—I am, naturally, assuming that the course is a general introductory course to be given to all engineering students. In the event that the course is taught to a restricted group primarily interested in the economics of some particular field, a discussion of general principles may well be tied to the facts of that field.

Having discussed what our course in the economics of engineering ought to be, I might make a comment regarding what I think it ought not to be. Such a course is very different from a course in accounting. This may seem to you to be an obvious enough remark that is hardly worth making; however, I was told by one engineering dean that a course of this nature was entirely uncalled for. What was needed was rather a course in cost accounting.

I heartily endorse the idea that engineering students should have a brief course in accounting; in fact, in my own teaching I have found it possible to do a more satisfactory job in the teaching of such an accounting course than in the teaching of the course in "Will it pay?"; but it seems to me that the two subjects are completely different, that they complement each other rather than duplicate. The engineer makes recommendations as to the economy of the proposal before the event; the accountant, on the other hand, deals with systematic rules for recording what has already happened. Much of the information which the engineer needs in his study of economy is not conceivably obtainable from the accounting records of an enterprise.

With these specifications for our course settled, I should like to discuss some of the questions of presentation and emphasis, on which my comments are suggestions rather than definite recommendations. The first question is in regard to the sequence of the material adopted for presenting the various aspects of "Will it pay?"

In an actual economy study, an elaborate program of fact-finding is likely to precede any financial calculations. Nevertheless, in presenting the subject to students I believe it is advantageous to start with financial calculation problems in which all of the facts

have been determined. The solution of a large number of problems of this nature illustrates the kinds of facts which it is necessary to find out in an economy study, so that the student approaches fact-finding with some knowledge of what he is driving at. We may draw an analogy here between the teaching of the economics of engineering and other engineering courses—for instance, structural engineering and its fundamental course, mechanics. In the practical design of a bridge, it is necessary to start with a study of the physical situation and the service to be rendered, including such matters as the loads to which the bridge is to be subjected. However, before the student gets to the subject of bridge design, he studies the fundamentals of mechanics, and he learns how to determine the stresses in members of bridge trusses under a given series of loads. He studies this as an abstract theoretical problem which is not related to the determination of the kind of external loads to which any particular bridges are subjected.

A second question of policy in the planning of our course is this: What method or methods of comparison shall be emphasized in presenting the financial calculations necessary to enable one to make a choice of different engineering alternatives? The answers which various instructors have given to this question illustrate two fundamentally different attitudes towards "Will it pay?" One attitude, particularly emphasized in the second edition of Professor Fish's *Engineering Economics,* is that we are dealing with the "problem of investment." The other attitude, typical of most engineering writers on matters of economy, is that we are dealing with the problem of "economic selection."

Specifically, in the typical situation where we are comparing the ultimate economy of two machines, one of which has a higher first cost and lower operating costs, we may make our comparison in several different ways. The two machines may be compared on the basis of the anticipated rate of return on the extra investment on the more expensive machine (this corresponds to the first point of view indicated); or (corresponding to the second point of view) the series of expenditures, including both capital and operating expenditures, may be reduced to an equivalent annual series (annual cost), or to an equivalent uniform payment, usually at the beginning of the series (capitalized cost).

I have used each of these three different approaches exclusively at one time or another, and have more recently tried to use all three of them in my presentation. No approach that I have adopted is entirely satisfactory. If calculations are all of one sort—for instance, capitalized cost—the student gets a decidedly one-sided picture; on the other hand, the introduction of several approaches to the solution of the same problem is almost always confusing, and it has so proved in my experience.

My feeling is that it gives the student a much more realistic picture if the problem of "Will it pay?" is presented to him as the problem of investment rather than of economic selection. On the other hand, it is possible to lay down a more logically consistent set of rules for calculation if either capitalized cost or annual cost is emphasized. Perhaps the answer is to make preliminary calculations on the basis of annual cost; and, in those cases in which a proposal with a higher first cost shows a lower annual cost, to calculate the rate of return on extra investment in excess of the interest rate already included in the calculation. In this connection it might be well if instructors in the field should standardize for their own purposes the meanings of such phrases as "rate of return," "per cent yield," and "profit," all of which are used in various meanings.

The third question of policy to be determined is the amount of emphasis to be given to compound interest mathematics. A personal experience of mine illustrates one point of view on this matter. At the time of my own introduction to the teaching of engineering economics I had come in, in the middle of the year, to fill out a term started by someone else. When my department head told me of the course I was inheriting, he said: "You may teach this engineering economics course yourself if you want to try it; otherwise, we shall give it to the mathematics department to teach as the mathematical theory of investment."

I have found that the idea expressed by my department head is not uncommon: that is, that a course in the economics of engineering is simply a course in the mathematics of investment, dressed up a little to appeal to engineers. My feeling is that this idea is all wrong. Important though it is, the study of compound interest mathematics alone, even though it be related to engineering situations, would give the student a very erroneous and one-sided picture. My own practice is to devote only enough time to the subject for the student effectively to learn how to use compound interest tables in the kinds of problems which he is later called on to solve. It seems to me that the mathematics of compound interest is one of those subjects which tends to sound more and more complicated the more you talk about it, and it is good psychology not to spend too much time on it.

A fourth question of policy is the amount of practice a student should be given in making cost estimates. On the theory that the accurate estimation of costs is a matter of major importance to engineers and that the engineering graduate's first contact with having to translate engineering units into dollar units would be in making estimates of cost, I devoted, at one time, as much as twenty-five per cent of the course to this subject; however, because of a

serious practical difficulty which arises in teaching cost estimating to a general group, I have greatly reduced the time devoted to this. The difficulty with teaching estimating is the same sort of difficulty that arises in trying to teach specification writing in a course in contracts and specifications; that is, a man is not competent to write specifications for, or make a cost estimate on, a structure that he doesn't know how to build. It is therefore necessary to find something to estimate with which all students are more or less familiar; with a group of junior engineering students, some simple framed structure is the best possibility; however, even with such a problem there are wide differences in the backgrounds of the students. If valuable class time is not taken to give the students a short course in building construction and plan reading, many of them are turned loose on the estimating problem with so little background as to make the results from it quite unsatisfactory.

Another question of policy relates to the background subjects of corporation finance, public utilities, and economics of government work. In a short introductory course such as I have always taught, there are obvious time limitations upon giving very much information about these subjects. Nevertheless, I feel that the course should not stop short at stimulating the student's curiosity about these fields, and it is possible to include a certain amount of useful information and to require the solution of a number of problems in which the student must combine his financial calculations for purposes of economy with considerations involving financial structure, public utility regulation, and the nature of economy studies for public works. I think if I had more time in my elementary course I should use it largely along these lines.

Incidentally, I think we have a definite social responsibility regarding public utility problems and the economics of governmental works. Not only because of the number of graduates who are employed by public utility companies, but particularly because of the tendency to increase social control of business, the problems of public utility regulation should receive some emphasis.

It is also very important, I think, to emphasize the fact that calculations of economy are as necessary in public works as in private enterprises, although it is essential to point out the practical differences between the two. The student should not get the idea that the consideration of the question "Will it pay?" is restricted to an organization created to make a profit for its owners. As a communistic friend of mine once remarked, problems of engineering economy are even more important in a communistic society than in a capitalistic one.

My last point relates to the nature of problems and examinations required in this course. A good many drill problems dealing

with financial calculations are required, just as a course in mechanics requires drill in the solution of problems dealing with force systems. Although these drill problems should be relatively simple, it is desirable to introduce one or more problems which bring in the complexities of actual situations. It has been my experience that in a small class a comprehensive problem involving fact-finding, cost analysis, consideration of judgment factors, and the writing of a brief report on some local problem on which the students may secure data—either individually or collectively—has many advantages in summarizing the work of the course. With regard to examinations, I have found it advantageous to combine problem type examinations, essay type examinations, and objective tests such as true-false examinations, in arriving at course grades. A particularly good type of examination question in this course involves the finding of a "horrible example" of incorrect reasoning on some matter related to engineering economics from the current technical press and asking the student to point out the mistakes in it.

In conclusion, may I repeat my conviction that organized instruction in the economics of engineering ought to have a definite place in the engineering curriculum. Such instruction should incidentally serve to stimulate the student's interest in business matters; its primary objective, however, should be to give him a point of view which will make him look for the economic aspect of engineering situations. Strenuous efforts should be made to present a realistic approach to the subject; at the same time, factual matters presented should be for the purpose of illustrating general principles rather than for their own importance. Details of emphasis and methods of presentation will probably always vary more widely than in a relatively standardized field like mechanics; despite this necessary and desirable individual variation, such opportunities for exchange of experiences as this meeting should result in improved teaching for all of us.

PETROLEUM ENGINEERING EDUCATIONAL PROBLEMS

By H. C. GEORGE

University of Oklahoma

The petroleum industry has been the last of our great American industries to become engineered, probably because of all of our industries it is most American, there being very few foreign-born workmen in it and practically no negroes. The native-born American has felt sufficient unto himself and has perhaps applied engineering principles to the industry without admitting the fact that engineering practice is involved.

However the rapid strides that the industry has made during the past twenty years in the adoption of scientific methods in oil finding, drilling, production, transportation, refining and marketing has given opportunity for engineers in increasing numbers. Yet even at the present time the average American oil company is devoting less than two per cent of its gross expenditures for engineering service, whereas the building, mining and many other industries expend from four to six per cent. The use of geophysical methods for oil finding, the improved type of equipment needed for drilling wells from one mile to two miles deep, the control and production of wells under pressure in excess of two thousand pounds per square inch, the construction of large pipe lines for oil and gas thousands of miles in length, the cracking and high pressure refining of crude and the development of a multitude of petroleum products for special purposes has necessitated the highest form of scientific and engineering skill. The demand for engineers in the petroleum industry will increase with the years, so that where one is employed at the present time, in a decade three or four will be needed.

"Petroleum engineering" is really something of a misnomer, for the petroleum industry not only needs petroleum engineers (mining engineers) but it needs and uses civil, mechanical, electrical and chemical engineers. However for the production branch of the petroleum industry, engineers in charge should have a sound basic training in geology, or they may mistake successful mechanical operation for efficient operation.

In general it may safely be said that for oil finding, the geological or mining engineer is best suited; for drilling and production, the petroleum engineer; for transportation, civil and mechanical

engineers; for refining, chemical or refinery engineers; and for marketing any of the above groups who have special aptitude and training for salesmanship.

Yet for the young engineer entering the petroleum industry, far more important than whether he is mining, civil, mechanical, electrical or chemical major, is that he has had a thorough training in basic science and engineering; special technicological courses should never be given at the expense of a thorough grounding in mathematics, physics, chemistry, geology, mechanics and thermodynamics.

I am inclined to agree with that group of engineering educators, who think that much better results would be secured in engineering education in our colleges and universities if the first three years of the four prescribed years required for a degree should have a curriculum in common to all engineering courses.

Petroleum production engineering in most of the schools, where major work of this character is given is classified as the petroleum elective group in mining engineering, and in most of the same schools where a petroleum refining elective is given, it is classified as chemical engineering. However at the University of Oklahoma, we have a School of Petroleum Engineering, where students may elect either production or refining. These two electives chiefly differ in that the former has a major in geology, while the latter has a major in chemistry.

Table I accompanying this report gives the subject matter of the courses in petroleum production engineering at the University of California, Stanford University, Colorado School of Mines, University of Oklahoma, University of Pittsburgh and Missouri School of Mines.

Petroleum Engineering Education has been discussed at the annual meetings of the American Institute of Mining Engineers for the past five years. The papers and discussion on the subject may be found published in *Petroleum Development and Technology* for 1926, 1927, 1928, 1929 and 1930.

Discussion

L. C. Uren: Some of us have been impressed with the need for a better understanding of the future place of the engineer in the petroleum industry. In academic work we are continually asked to advise students as to the opportunities in different directions, to guide them in their selection of professions, and it would be extremely helpful to those in academic lines of work to have the opinion of engineers from the industry relative to the need for petroleum engineers.

TABLE I

SHOWING PERCENTAGE OF TOTAL TIME ALLOTTED TO VARIOUS SUBJECTS IN PETROLEUM PRODUCTION ENGINEERING CURRICULA AT VARIOUS INSTITUTIONS AND THE AVERAGE FOR EACH SUBJECT

Subject	Univ. of Calif.	Stanford Univ.	Colo. School of Mines	Univ. of Okla.	Univ. of Pittsburgh	Missouri School of Mines	Average Requirement
Mathematics	8.2	5.3	10.7	12.5	11.6	11.4	10.0
Physics	8.2	2.8	6.3	6.6	8.7	7.6	6.7
Chemistry	15.0	4.2	13.2	5.3	21.0	17.7	12.7
Geological Sciences	21.1	12.3	9.4	11.8	14.5	12.0	14.1
Drawing	3.4	8.4	6.3	4.0	1.5	3.8	4.6
General Engineering	14.3	10.5	15.7	18.4	2.9	12.6	12.4
Mechanical Engineering	4.1	8.1	5.0	13.8	—	5.1	6.0
Civil Engineering	—	—	1.2	—	—	3.2	0.7
Mining and Metallurgy	5.4	3.5	1.2	2.0	—	0.6	2.1
Petroleum Engineering	6.1	7.4	12.6	8.5	27.5	7.6	11.6
Military Science and Physical Education	5.4	—	3.8	2.6	2.9	5.1	3.3
Economics, Business Law, Political Science	1.4	10.3	1.9	7.2	5.1	3.8	5.0
English, Foreign Language, History, Public Speaking	—	10.8	5.7	4.0	4.5	7.6	5.4
Thesis	2.7	1.8	—	—	—	1.9	1.1
Electives	4.7	14.4	7.0	3.3	—	—	4.3
Totals, per cent	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total No. "Units" Required for Grad.*	147	190	159	152	138	158	151†
Duration of Course	4 yr.	6 yr.	4 yr.	4 yr.	4 yr.	4 yr.	

* The "unit" is 1 hr. of lecture or 3 hr. of laboratory work per week for 1 semester.

† Average of 4-year curricula.

SUMMARY OF ENROLLMENTS IN 145 ENGINEERING SCHOOLS IN THE UNITED STATES IN 1930–1931

Curricula and Courses	Freshmen	Sophomores	Juniors	Seniors	Total Undergraduates	Total
Electrical	6,662	4,768	3,973	3,162	18,565	19,992
Mechanical	5,322	4,217	3,287	2,227	15,053	15,684
Civil	4,452	3,563	3,154	2,644	13,813	14,534
Chemical Engineering and Chemistry	3,705	2,768	1,956	1,420	9,949	11,013
Mining and Metallurgy	940	712	647	472	2,771	2,944
Geology and Geological	109	72	67	42	290	314
Petroleum	240	211	176	97	724	790
Totals	25,332	19,631	16,262	12,161	72,386	78,685

Is the industry going to require a continually growing number of engineers in the future years, or have we perhaps reached equilibrium in that regard?

In anticipation of this meeting, I undertook to canvass opinion among a number of engineers of my acquaintance and I have been rather astonished to learn that the expenditure on engineering salaries in the producing branch of the oil industry is extremely low. I have figures from eight or 10 of the larger oil companies and it seems to be a fair statement on the basis of these figures to say that the average American oil company is devoting less than 2 per cent of its gross expenditures in oil production to the payment of engineering salaries.

A few examples will be of interest. I shall not mention names of individual companies, but one large Mid-Continent company is spending slightly less than 1 per cent of its gross expenditure—that is, less than 1 per cent of the total expenditure in the producing department—on engineering salaries and about as much on engineering research, which might properly be regarded as a phase of its engineering work. Another Mid-Continent company is spending about 1¼ per cent on engineering salaries. A large California Company is spending about 1½ per cent. The largest figure that has come to my attention is that of an important Rocky Mountain and Mid-Continent company that is spending a little more than 6 per cent, but that is apparently an extreme case.

The petroleum producing industry is a highly technical business in these days. It is spending in excess of $500,000,000 annually in new development work and in the operation of properties for oil production and it would appear to many of us that every dollar of this expenditure should be regulated and controlled by engineers. Other engineering industries are spending much higher percentages than those I have just indicated. The building industries, for example, commonly allow from 4 to 6 per cent of their total expenditure for engineering design and supervision.

I have similar figures from a number of mining companies, copper-mining companies particularly, in which the figure runs from 4 to 6 per cent, and here we have the petroleum producing industry, more technical perhaps than either of these other fields, spending less than 2 per cent.

The demands on the engineering profession in the field of petroleum production appear to be increasing. We are ever venturing into more technical methods, the gas-lift, repressuring of properties, secondary methods of recovery in general, and waterflooding; all demand a much higher technique than the industry has made us of in past years.

Many operations on the oil property involve a high order of engineering skill. Design and construction, and operation of pipe lines for oil and gas transmission, and the problems of dehydration and storage are all highly technical matters in these days. It would seem that the oil industry has need of a greater number of engineers to properly develop and control these processes. Deep drilling, with increased weight of equipment, and many other problems that have arisen in the development of drilling methods, would seem to demand a higher order of engineering than we have had in years past.

The industry is turning to its engineers for administrative recruits. Some of the most responsible positions in the administrative field are now recognized as properly open to engineers. Field superintendents, managers of oil companies, directors, and even presidents of oil companies are in these days being recruited from the engineering field. It would seem that further transfers of engineering personnel into these positions might leave greater opportunities in the future for new men in the industry from the general engineering ranks.

These are but a few thoughts that have come to me in this matter and they all seem to point to the conclusion that the petroleum industry of today is really under-engineered, that oil companies might find it profitable to add materially to the number of engineers in their employ. Presumably they employ engineers because it is profitable for them to do so. If an oil company finds it profitable to employ 10 engineers, would it not possibly be more profitable to employ 20, and if 20 is better than 10, perhaps 30 is better still.

Obviously there is a balance there beyond which it becomes uneconomical to employ additional personnel, but I have a feeling that we have not nearly reached this economic balance at the present time. We have the habit of going along with the present situation, with the existing order of things, without really looking into the actual needs and I believe that if a real study of this situation were made, it would be found that the oil industry today is underengineered.

C. M. Leonard: There are several points in Professor George's talk that I should like to emphasize:

1. One of them is the trouble in introducing any engineering in the petroleum industry in the past. Of course, during the first development of the petroleum industry, methods of production, transportation, and refinement were not reported, due to the fact that a large amount of wells produced in a..... ..... was not material. However, due to the development of the industry in several respects, such as pressure

drilling and transportation, engineering can be applied more effectively. That, of course, has been one of the troubles in teaching petroleum engineering, in order to place the man after graduation in jobs dealing with engineering work.

2. Another point brought out by Professor George in reference to not sacrificing engineering work in order to obtain more petroleum is that if we have our engineers go into petroleum work, they should be thoroughly grounded in the different phases of engineering; perhaps in all phases—mechanical, electrical, civil, and chemical in particular, especially if the student is preparing to go into that kind of work. I might give a brief outline of the petroleum work offered at A. & M. I think that we all know that Oklahoma University has a very good petroleum school; one that they should be proud of. Facilities at A. & M. are not so extensive, and our petroleum work is offered as an option in mechanical engineering. The freshman and sophomore work is the same. Petroleum work starts in the junior year. We have about 14 hours of petroleum work which is more or less general in character, not specializing in drilling, production, or refining. We do not, however, have any management courses such as spoken of by Professor George. The work given in different branches of geology and chemistry is arranged so that the student gets a more or less general knowledge of several branches, and he may, if he desires, put in special subjects in any of those branches in his elective. That sort of course gives the student a chance to specialize as he desires. Of course, petroleum will draw students of several classes, due to the fascination it has for the individual. We find, however, that students taking petroleum optionally are of a higher class of students in general. They are students who have had some, or perhaps several, years in practical work, as in drilling, refining, or salesmanship, and they know definitely the troubles and tribulations of petroleum engineers. Of course, before graduation, we require not two, but one summer's work in engineering, and in general the student graduating in Petroleum Engineering has had several summers' work, and perhaps several years.

R. G. Paddock: In looking over the field of the petroleum industry, one is rather struck with the difference in the problems that the graduate will encounter when he gets out into the work from those encountered by the graduates in other branches of engineering. The majority of positions are in the field and will require a type of man somewhat different from the average engineering graduate. I think that you will find that in the usual engineering class only a very small percentage of the graduates are really fitted for executive positions in field work. The life in the field is more

or less strenuous and full of hardship, and a great number of men are not particularly fitted for that kind of life. Schools that would have courses in petroleum engineering should insist upon students getting some practical experience early in their course, which would greatly eliminate the disillusionment of the prospective petroleum engineers later on in their career. If a man goes out into that type of work without any previous experience, unless it should happen to be to his particular liking, the chances are that he would become dissatisfied with the position and not advance. It is better to find it out early. The man at the end of his freshman year, who takes a course in field work and finds it distasteful to him, still has time to change to some other line of endeavor without any particular loss of time. In field positions in the petroleum industry one will find a condition very similar to conditions in the industry which I recently left, which is the public utilities industry. The public utilities industry is more or less a new industry and you will find that in the petroleum industry, most of the older executives of the industry are practical men and place special emphasis on practical experience. I know of a number of cases where technical men have been discriminated against in favor of men with practical experience. There is much more liklihood of encountering such discrimination in field positions than in engineering postions or positions of a sales or executive character.

I think also that the petroleum industry has been rather slow in adopting any type of method for adapting the graduate to that particular industry. Some of the companies have provided student training courses, and watch their men for some time after they get through the University. Quite a number of them have found that this is not particularly satisfactory, and they have adopted the policy of hiring a man, putting him on the job, and letting him dig for himself. If he is particularly fitted for that type of work, they feel he will come to the top. I think, possibly, that the problems of the after training of engineering graduates in the petroleum industry are more complex than they would be in almost any other industry. The industry is so filled up with other types—practical men—that it is very difficult to change over within a very short time. However, eventually the engineer should gain proper recognition as he has done in other lines of industry.

Dean J. H. Felgar: In engineering education there is a conflict between the prerequisites for a subject and the student's desire to get certain courses. If he fails to take trigonometry and leaves it to the latter part of the course, he has a greater struggle to pass the courses which depend on trigonometry. Of course, as in life, he gets some trigonometry as he studies the course. Many

times the administration is kept busy adjusting the courses and their prerequisites. It can never be perfectly done.

There are very few "time servers" on the engineering faculty. There is a consistent effort, I believe, by each faculty member to work to the limit of his ability. The reputation of a school depends on the character and reputation of its faculty; and a student of less ability graduating carries with him that reputation. But the real success of a school is the accomplishment of its graduates.

SIGNIFICANCE OF ENTRANCE REQUIREMENTS FOR THE ENGINEERING COLLEGE AT THE UNIVERSITY OF WASHINGTON

By AUGUST DVORAK

University of Washington, Seattle, Washington

AND

RUFUS C. SALYER

University of Washington, Seattle, Washington

Presumably every professional college dean dreams of the day when every student matriculating in his college will possess the necessary ability, previous training, ambition and industry to do successfully the work of his college. When college budgets are being carefully scrutinized, the enrolment of students who have little or no possibility of reflecting credit on their colleges must be characterized as "poor business." When higher education is being evaluated by tax-payers and patrons who at present consider the burden of supporting education to be excessive, the elimination of students because of low attainment in their college work is hardly conducive to increasing public support for higher education. The fact that students dropped for poor work had previously satisfied the entrance requirements of their respective colleges renders the elimination of students for low scholarship difficult to justify. Most laymen assume that the college faculties are best fitted to judge whether in their respective colleges the attainments of the students are adequate to warrant their certification for professional work. Likewise most laymen assume that when college faculties prescribe requirements for matriculation in different colleges, fulfilling these requirements fits the students to succeed in the work of the colleges. When only one, approximately, of every three students matriculating in our colleges ultimately graduates, question may well be raised as to the significance of the matriculation requirements.

To be able to determine with fair accuracy before the student registers in a particular college the likelihood of his success in the profession would be of value to the student, to his parents, to the institution and to the cause of higher education generally. The number of "prediction" studies in book and periodical publications is evidence that the need of information relative to students' potential success is recognized. In the main such studies have tended

to confine themselves to the prediction of success, determined by college grades or marks, from single variables. Thus there are to be found studies which attempt to predict the college success of students by means of *zero order* correlations with (*a*) intelligence test scores, (*b*) chronological age, (*c*) total high-school record, (*d*) high-school record in special subjects, (*e*) aptitude tests, (*f*) objective tests in special subjects, (*g*) objective examinations over the entire high-school course, (*h*) special interest tests, and (*i*) essay-type entrance examinations. The conclusions reached in practically all such studies are:

1. Each of these single variables correlates to some degree with college success.

2. The correlations between college success and these single variables are too low to permit the admission or rejection of potential students without serious errors in the cases of individual students.

3. No single criterion is a safe basis for the selection of successful students.

The problem of predicting students' college success is complicated by the fact that colleges enrol students from many high schools. These high schools utilize different systems of grades or marks. Furthermore these high schools establish standards usually peculiar to themselves. Some states have a single system for reporting students' marks or grades. Few, if any, states have taken the steps necessary to maintain a uniform standard in the assigning of grades in a system common throughout the state. A uniform standard for the assigning of marks or grades in such a system is apt to be administered subjectively by the individual teachers. The unreliability of marks or grades as usually assigned has frequently been demonstrated in educational measurement literature. Thus the professional college is faced with the task of selecting its students on the basis of data which are recognized to be only partially reliable and which are stated in various systems of nomenclature and derived by various standards of evaluation. The low correlations usually found between the ratings which determine college success and the ratings on entrance requirements are due in part to the inaccuracy or unreliability of the ratings correlated.

In this study the writers recognized that when several independent or semi-independent variables correlate with a dependent variable, if these variables have low intercorrelations, these several variables may be combined into a group which will give a much higher correlation with the dependent variable than will any one of the independent variables alone. In order that these independent variables may be combined into an efficient group their significance must first be evaluated. When combined into a group each variable

is then given only such weight as is determined from its independent significance. The significance of the independent variables is determined by the partial correlation technique, the results of which permit the computation of a regression coefficient. The correlation of the group of independent variables with the dependent variable is computed by the multiple correlation technique.

Through the cooperation of Registrar E. B. Stevens and Professor E. R. Wilcox, Engineering Freshman Adviser of the University of Washington, data for this study were made available. The data secured from the records of the entire 1928–29 freshman engineering class at the University of Washington consisted for each student of

1. (X_1) Average freshman scholarship record in the College of Engineering.
2. (X_2) Average scholarship in all high-school English work.
3. (X_3) Average scholarship in all high-school natural science work.
4. (X_4) Average scholarship in all high-school social science work.
5. (X_5) Average scholarship in all high-school mathematics work.
6. (X_6) Percentile rating in the University of Washington Intelligence Test.
7. (X_7) Percentile rating in the Iowa Mathematics Aptitude and Training Tests.
8. (X_8) Percentile rating in the Iowa Physics Aptitude and Training Tests.

In computing variables 1, 2, 3, 4, and 5 from grades or marks the values used were A = 4, B = 3, C = 2, D = 1, E = 0. Variables 6, 7 and 8 were computed in percentiles. The intercorrelations of these eight variables are presented in Table I.

It is clear from the intercorrelation coefficients that the correlation of each variable with University freshman scholarship is influenced by the effect of the other variables. In other words, the so-called independent variables are only semi-independent. To determine the correlation of each semi-independent variable with

TABLE 1

INTERCORRELATION COEFFICIENTS OF THE EIGHT VARIABLES

Variables	2	3	4	5	6	7	8
1. Univ. freshman eng. ave.	.353	.457	.335	.488	.374	.577	.546
2. H. S. English ave.	—	.562	.638	.612	.368	.329	.318
3. H. S. natural science ave.	—	—	.541	.601	.307	.281	.377
4. H. S. social science ave.	—	—	—	.519	.288	.260	.328
5. H. S. mathematics ave.	—	—	—	—	.299	.391	.377
6. Psychological test ranking	—	—	—	—	—	.621	.522
7. Mathematics placement tests	—	—	—	—	—	—	.695
8. Physics placement tests	—	—	—	—	—	—	—

university freshman scholarship the effect of all the other variables must be partialled out. This was done with the results found in Table II.

TABLE II

PARTIAL CORRELATION COEFFICIENTS OF SEVEN VARIABLES WITH UNIVERSITY FRESHMAN ENGINEERING SCHOLARSHIP AVERAGE

(1) Univ. freshman ave. and (2) H. S. English ave.	$r_{12.345678}$	$= -.04270$
(1) Univ. freshman ave. and (3) H. S. nat. sci. ave.	$r_{13.245678}$	$= .20221$
(1) Univ. freshman ave. and (4) H. S. soc. sci. ave.	$r_{14.235678}$	$= .01564$
(1) Univ. freshman ave. and (5) H. S. math ave. ..	$r_{15.234678}$	$= .17756$
(1) Univ. freshman ave. and (6) psy. test percentile rank	$r_{16.234578}$	$= .05496$
(1) Univ. freshman ave. and (7) ave. rank Iowa Math Apt. and Training Tests	$r_{17.234568}$	$= .30149$
(1) Univ. freshman ave. and (8) ave. rank Iowa Phy. Apt. and Training Tests	$r_{18.234567}$	$= .16922$

The zero order correlation coefficients found in Table I are much larger than they would have been if the effect of other variables working simultaneously had been known and accounted for. The negative partial correlation coefficients found for high-school English and intelligence tests do not indicate that engineering students do not need to know English or to have intelligence. High-school English includes considerable work in English literature. If a student is so constituted that he shows much promise in literature the likelihood is that he may or may not be so constituted as to show promise in the coldly scientific, highly accurate and essentially mathematical work in engineering. In the case of the intelligence test the facts are that intelligence has contributed to all the seven other variables studied. The rating on intelligence therefore is superfluous. The negative partial coefficients found (— .0427 and — .05496) are in all probability indications of a zero relationship, being well within the probable error of r from zero.

The regression coefficients of the seven semi-independent variables were computed and are presented in Table III.

The regression coefficients are in substance the relative significance or weights to be assigned to the seven variables in predicting University freshman engineering scholarship. To predict a stu-

TABLE III

REGRESSION COEFFICIENTS FOR SEVEN VARIABLES

High-school English	$b_{12.345678}$	$= -.06087$
High-school natural science	$b_{13.245678}$	$= .26912$
High-school social science	$b_{14.235678}$	$= .01765$
High-school mathematics	$b_{15.234678}$	$= .23836$
University intelligence test	$b_{16.234578}$	$= -.00139$
Iowa Mathematics Test	$b_{17.234568}$	$= .01400$
Iowa Physics Test	$b_{18.234567}$	$= .00649$

dent's freshman engineering scholarship when data for the seven variables were available one would use the formula: (stated in deviation form) $x_1 = -.06087\ x_2 + .26912\ x_3 + .01765\ x_4 + 23836\ x_5 - .00139\ x_6 - .014\ x_7 - .00649\ x_8$.

The Multiple Correlation Coefficient (R) in this case is +68. In other words, when the variables 2, 3, 4, 5, 6, 7 and 8 are combined in a team in which each of the variables is given its proper weight and the group or team is correlated with Variable 1 (University freshman engineering scholarship average) the coefficient is considerably larger than any coefficient secured by correlating any single variable with Variable 1 (See Table I) and is higher than the correlation coefficient of +.50 found between total average high-school record and average freshman engineering record.

When freshman engineering scholarship was computed for 77 engineering students and the predicted scholarship was compared with the scholarship actually attained by these students the P.E. of the predicted scholarship was found to be .37 of a grade. The P.E. of the unweighted high-school record was .76 of a grade. The errors of prediction when the weighted formula was used were less than 50 per cent as large as when the high-school record was used without weighting.

When the formula for weighting the entrance requirements was applied to the entrance records of a group of students who were on the "dropped" or "warned" lists for poor scholarship, the results secured from the formula indicated clearly in the case of 84 per cent of the students that their scholarship would be below the standard necessary to keep from being on either of these lists.

In Table III the weights (regression coefficients) are computed for the first five variables on a five point scale, while for variables 6, 7 and 8 the weights are computed on a percentile scale. To determine the relative significance of the seven variables the last three should be multiplied by 20. The relative significance of the seven variables for predicting freshman engineering scholarship becomes:

TABLE IV

THE RELATIVE SIGNIFICANCE OF SEVEN ENTRANCE REQUIREMENTS FOR PREDICTING THE SCHOLARSHIP OF FRESHMAN ENGINEERING STUDENTS

	A	B*
High-school English	−.06087	− 3.4
" natural science	+.26912	+ 15.2
" social science	+.01765	+ 1.
" mathematics	+.23836	+ 13.5
University intelligence test	−.0278	− 1.6
Iowa mathematics tests	+.280	+ 15.9
Iowa physics tests	+.1298	+ 7.3

* In Column B the lowest value (.01765) was assigned a value of 1 and other values were raised proportionately to enable comparisons from indices involving whole numbers.

Clearly, of the data available at the time of matriculation in the engineering college at the University of Washington, those most significant of the student's subsequent success are the high-school natural science and the high-school mathematics scholarship averages and the Iowa Mathematics Test and Iowa Physics Test scores. The student's high-school natural science record is 15.2 times as significant and is his high-school social science record. The rating the student makes on the Iowa Physics Test is 7.3 times as significant as is his high-school social science record. Other comparisons of significance are available in Table IV.

THE TETRAHEDRON TEST OF POWER TO VISUALIZE

By W. J. McCAULEY

With Introduction by C. V. Mann

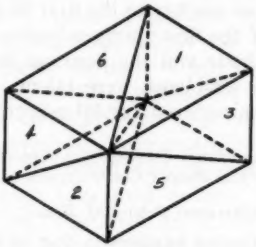
In designing the tetrahedron test which is described in this paper, Mr. W. J. McCauley has contributed a most valuable instrument to the field of aptitude testing of engineering students. In my opinion this test will come to find a place of great usefulness in making selection of entering students for classes that are to be sectioned on the basis of ability. The test is one of several recently developed which purport to measure visualizing ability, and this particular test measures the quality in a way very closely related to the manner in which engineers both make and read drawings. This paper is a résumé of a fifty page unpublished report which Mr. McCauley has written. Copies of this report and of the test may be had from Mr. McCauley, 459 Cottonwood Street, Globe, Arizona. Readers of the Journal of Engineering Education are urged to make a careful study both of this report and of the test and results achieved through its use.

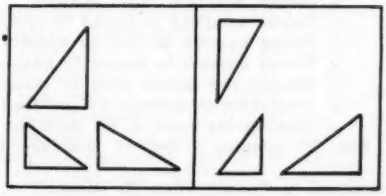
Engineering is that branch of human endeavor which seeks to discover, understand, and control the laws, forces, and materials of nature and to apply them to the beneficial uses of mankind. The work of the engineer is largely concerned with static structures and machines. Since these occupy three-dimensional space, and since they must exist in the mind of the engineer before they can exist in reality, and since the preliminary materialization of these structures, and the language of thought transference concerning them, are drawings in two dimensions, it is reasonable to suppose that one of the fundamental traits necessary to the engineer is the ability to visualize in either two or three dimensions, to perceive relationships in both, and to pass from one to the other.

It was in the belief that this trait exists, is innate and measurable, and peculiar to the typical engineering mind, that the author undertook to develop a direct test of engineering aptitude. Many different tests based on the above ideas and forms of the present test have been studied, and after many changes and a long period of evolution the test in its present form was developed. The test as it now stands is as near perfect as it can be made until many more hundreds of cases are studied.

The test in the form used until the present time consisted in the association of a set of six, right tetrahedrons with their three-view orthographic projections. These were cut from a block of wood $1'' \times 1\frac{1}{2}'' \times 2\frac{1}{2}''$ by making three saw cuts through each diag-

onally opposite pair of edges. Each student was given a set of these tetrahedrons properly numbered and 144 drawings, representing every possible position these could occupy with respect to the planes of projection, oblique views not being considered. The score was the number of correct associations made in a given length of time.





The early results with this form were so encouraging that about a year ago an attempt was made to answer the question. "Does this test have sufficient merit as a prognosis of engineering aptitude to warrant a thorough and painstaking investigation?" To this end the coöperation of the University of Arizona and the Missouri School of Mines were solicited. The author was attending the former as a graduate student, and the latter selection was made on account of the fact that Dr. Clair V. Mann of that institution has devoted a great amount of time to this phase of aptitude testing and is an authority on the subject. The author is deeply indebted to him for his hearty coöperation.

The preliminary investigation was confined almost entirely to a study of the relationship between scores on the test and achievement in the subject of descriptive geometry. This subject was selected for the reasons that it is given in the freshman year and thus affords a wider range of ability than is to be found in more advanced studies where natural selection has eliminated all but men of demonstrated ability; and, it is the common opinion of engineering educators that ability in descriptive geometry is the best criterion of future engineering success available at the freshman

level. This contention was borne out by a study of the relationship between scores in this subject and higher engineering studies made by the author at the University of Arizona.

The test was administered to about 75 freshmen at the Missouri School of Mines, and 100 engineering students at the University of Arizona. At the former the test was continued until every student had submitted an answer to the first 60 problems of the test. The score at the end of the first thirty minutes, and every ten minutes between the half hour and the hour, as well as the total time required to attempt 60 problems, were taken. At the latter institution the test was administered for 30 minutes only.

TABLE OF CORRELATIONS BETWEEN DESCRIPTIVE GEOMETRY AND TETRAHEDRON TEST SCORES AND OTHER COEFFICIENTS OF INTEREST

(Missouri School of Mines)

Descriptive Geometry	× Correct solutions in first 30 minutes	.58
	× Correct solutions in 60 minutes	.66
	× Correct solutions in second 30 minutes only	.71
	× Wrong answers in first 30 minutes	—.25
	× Wrong answers in second 30 minutes only	—.46
	× Minutes per correct solution (total time)	—.66
	× Total time to attempt 60 problems	—.52
	× Total errors made in 60 attempts	—.51
Correct solutions first 30 minutes × Correct solutions (second 30 minutes)		.78
Wrong (first 30 minutes) × Correct (first 30 minutes)		—.30
Wrong (second 30 minutes) × Correct (second 30 minutes)		—.45
Total errors in 60 attempts × Total time to make 60 attempts		.26

(University of Arizona)

Odd-Even coefficient of reliability	.94
Descriptive Geometry × Correct solutions (30 minutes)	.47
Descriptive Geometry × Intelligence (American Council Tests)	.43
Intelligence × Correct solutions (30 minutes)	.32

The coefficients obtained at the University of Arizona were somewhat lower than at the Missouri School of Mines, but this was due to the fact that the author conducted the investigation and his methods were admittedly somewhat at fault. On the other hand, there is some evidence to indicate that Dr. Mann's coefficients were lower than would result from an unselected group of subjects. Dr. Mann administered the test to a section of his descriptive geometry group which had been selected on the basis of other tests. The latter have since been shown to have a significant relationship to the tetrahedron test. Thus one is justified in believing that the coefficients found with this group are lower, in an amount governed by some function of the elements these tests have in common, than would result with a perfectly unselected group.

A careful study of every report sheet was made and as a result of this both the dimensions of the tetrahedrons and the technique of administration have been changed. The new size is, $1\frac{1}{8}'' \times 1\frac{1}{2}'' \times 2''$, and one hour has been decided on as the correct length of time the test should be given, and the score for the last forty-five minutes only will be used for predictive purposes.

The best predictive value of the test for sectioning classes in descriptive geometry was obtained by the use of scores from the second thirty minutes of testing. When these are used a correlation with the criterion of .71 is obtained. Had Dr. Mann divided his group of 70 men, on which scores for both the test and descriptive geometry were available, into two groups of 35 men each on the basis of the test, he would have misplaced 13 men, and only five of these could have been said to have been misplaced to any serious degree. When these men are divided into ten groups of seven men each on the basis of the test, and again on the basis of descriptive geometry grades, we find that the test places them in regard to the criterion as follows:

Exactly correct	20 men
One step removed	18 men
Two steps removed	17 men
Three steps removed	5 men
Four steps removed	6 men
Five steps removed	3 men
Six steps removed	1 man

As a prognosis of engineering aptitude the indications are, from a study of 35 upper classmen at the University of Arizona, that seventy-five per cent of the men who are above the mean on the test will also be above the average of their group in general scholastic achievement. A study of this phase of the test will consitute a part of the next step of the investigation.

The data are as yet insufficient in number and certain weaknesses both in administration and design are indicated by the study, but the results show that the test may be used as a means of sectioning classes in descriptive geometry at the beginning of the course, and a further study of the test as a prognosis of engineering aptitude is justified.

NEW MEMBERS

BENNETT, J. GARDNER, Professor of Civil Engineering, Lewis Institute, Chicago, Ill. W. C. Ebaugh, F. L. Bishop.

BROWN, WALTER F., Associate Professor of Electrical Engineering, University of Toledo, Toledo, O. Ivan F. Zarobsky, J. B. Brandeberry.

CASE, ALLANDO A., Associate Superintendent of Shops Laboratories, Georgia School of Technology, Atlanta, Ga. R. S. King, W. V. Dunkin.

HALSEY, HUGH, Instructor in Physics, The Cooper Union, New York City. Geo. F. Bateman, Albert Ball.

HOLLAND, A. DINSMORE, Assistant Professor of Experimental Engineering, Georgia School of Technology, Atlanta, Ga. H. W. Mason, Richard A. Trotter.

REESE, RAYMOND C., Part-Time Instructor in Civil Engineering, University, City of Toledo; Chief Engineer, Secretary, Hausman Steel Co., 1931 Sussex Place, Toledo, Ohio. J. B. Brandeberry, Ivan F. Zarobsky.

SMITH, RICHARD H., Professor of Aeronautics, Massachusetts Institute of Technology, Cambridge, Mass. F. Alexander Magoun, W. H. Timbie.

SWETT, GEORGE W., Professor of Machine Design, Massachusetts Institute of Technology, Cambridge, Mass. F. Alexander Magoun, W. H. Timbie.

VAN HOUTEN, ROBERT W., Instructor in Civil Engineering, Newark College of Engineering, Newark, N. J. H. N. Cummings, P. E. Schweizer.

VOSS, W. C., Professor of Building Construction, Massachusetts Institute of Technology, Cambridge, Mass. F. Alexander Magoun, W. H. Timbie.

ZERBAN, ALEXANDER H., Instructor in Mechanical Engineering, Pennsylvania State College, State College, Pa. H. A. Everett, Fred C. Stewart.

120 new members this year.

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

June Meeting: While at this writing the program for the 1933 meeting of the Division of Engineering Drawing is not complete, there is every assurance of a profitable and interesting meeting. Already there has been arranged a joint meeting of the Division with the English teachers for a discussion of "The Engineering Report" as follows:

"The English of the Engineering Report," "The Illustrations of the Engineering Report," "Common Ground of Drawing and English." It is planned to have this session the annual dinner meeting of the Division of Engineering Drawing, and at this time awards will be made to the winners of the 1932 drawing competition.

Among other interesting possibilities for the meeting have been suggested an exhibition of old works on Descriptive Geometry and Engineering Drawing, exhibitions of sets of drawings typical of various engineering projects from the various fields of engineering, an exhibition of drafting instruments, ancient and modern, and displays of drawings illustrating the development of engineering drawing, both as to the type of draftsmanship, the style of representation, and the media on which drawings were made.

A Museum of Engineering Drawing: A project which might well engage the attention of the Division of Engineering Drawing is the collection, preservation, and display of the historic material of Engineering Drawing. Doubtless, if properly sponsored, a suitable central museum of permanent character would be willing to cooperate in this work of preserving for the use of teachers and for the interest of future generations the valuable and interesting story of the development of Engineering Drawing. There must be considerable material still available in files, and in private collections, which could thus be brought to light and made available.

SECTIONS AND BRANCHES

A majority of the S. P. E. E. members of this district voted for a permanent organization of a **Colorado-Wyoming Section.** At the present time the question of a meeting in the spring is being considered.

A combined meeting of the **Maine Branch** of the S. P. E. E. and the Science Seminar was held in Merrill Hall, Wednesday, March 1, 1933. There were 42 in attendance.

Professor Charles F. Scott of Yale University spoke on "Professional and Public Relations of the Engineer."

I. H. PRAGEMAN,
Secretary.

NEED OF SOCIAL-MINDEDNESS AMONG ENGINEERS *

BY ROBERT C. CLOTHIER, *President*

Rutgers University

This is the age of engineering. We should be hard put to it to express to the engineer what society owes him for what he has accomplished in recent years. Through his skill wealth beyond the dreams of avarice has been created. Physical comforts and conveniences are ours of which our parents a short generation ago could have hardly conceived. Leisure is ours in even greater measure, in itself a great blessing to mankind provided mankind learns how to use it. Distance has been annihilated; no longer are we sixty days away from Europe by barkentine, or thirty days away by clipper. We can cross the Atlantic Ocean in four days by steamship; thirty hours by airplane; a few seconds by radio or cable. The world has become an intimate community of nations.

It is fair to say that the engineer has contributed to human welfare as much as the physician—and I know no greater praise than that.

Because such great progress has been made in the mechanics of living we are sometimes tempted to confuse mechanical achievement with social achievement. Increasingly during recent years the engineer himself has come to realize the danger of this temptation. There are values in life which cannot be touched by technique and processes no matter how skilled and expert they may be.

* Presented at a meeting of the Middle Atlantic Section, December 3, 1932, at the Newark College of Engineering.

Formerly engineering education stressed technical proficiency. Now we know that technical proficiency alone is not enough. It is of equal importance to the engineer that he be skilled in human relationships. The engineer must be expert in materials and processes but he must also be expert in handling men.

It is well that we have developed tools of incredible efficiency. Yet we know that no matter how wonderfully the tool may be made it is no more efficient than is the workman using it. The efficiency of the workman depends in turn upon his attitude and upon his morale and these in turn upon leadership.

Ability to work with men is not something learned out of books. Rather it is a point of view, so much believed in as to constitute part of a person, which is compounded of an interest in people, a sense of inspiration, decisiveness, a sense of humor, and an appreciation of the Golden Rule which is acquired not through study but primarily through association with teachers who are themselves experts in human relationships. This point of view is in keeping with the trend in education generally.

For society is concerned not only with what the men *know* who come from our colleges. It is deeply concerned with what they *are*. We do need men who are intellectually and technically expert, but we need men too who are not egocentric but are socially-minded and conscious of their responsibility to society; men who have courage and determination; men who have a grasp and understanding of spiritual values.

Such things as these will never yield to the slide rule and the micrometer; yet they are essential in the craft of the engineer. Because the engineer works with facts he is thought of by many as a scientist who also works with facts; but because he builds a modern civilization not only out of brick and steel, but also out of the aspirations and skills of men we should think of him too as an artist.

No profession is more exacting in thoroughness and accuracy than is that of the engineer. There is no room in the profession for a man who is superficial in his workmanship. In engineering education, as in all education, the student should place his emphasis upon the substance, upon honest achievement, rather than upon what seems to be achievement. There is danger in employing symbols to indicate accomplishment. We of the colleges continue to give examinations and mark them and, in consequence of these grades, to award students certain credits and when they accumulate sufficient credits to grant them degrees and diplomas. The futility of it all is suggested by the realization that by so doing we unconsciously encourage the student to work for the symbols rather than for the substance of the achievement which those symbols are

intended to represent. The student has a responsibility not to yield to this temptation, not to work for grades and degrees, but to work to acquire mastery, and it is our responsibility, we who teach, to inspire him to do so. The development of the all-around man is the responsibility of the College of Arts and Sciences. It is not less the responsibility of our professional and technical schools. It is the responsibility of our schools of engineering.

In 1762 the Trustees of one of our colonial colleges issued the following statement:

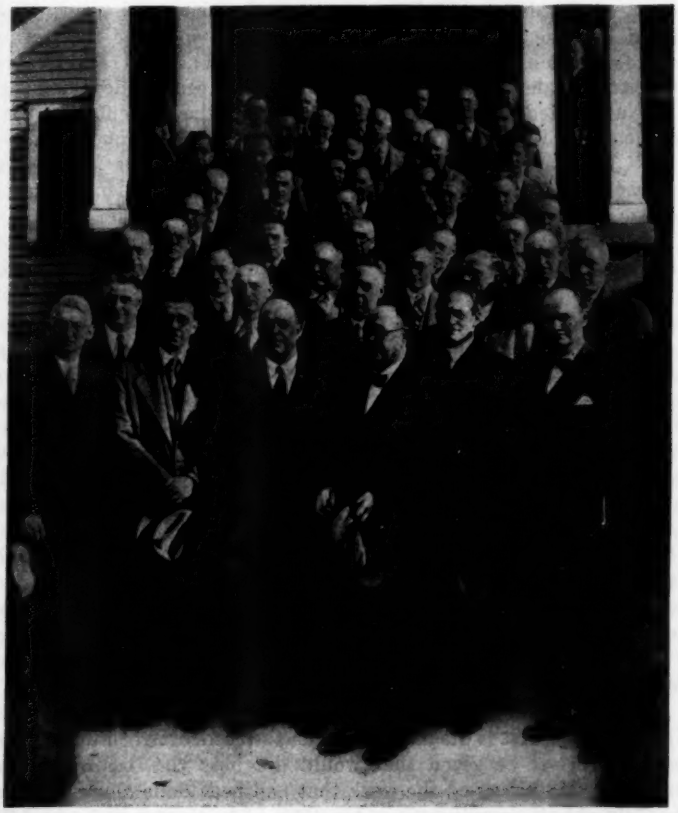
> "It will suffice to say that the Two principal Objects the Trustees had in View were Science and Religion. Their first Concern was to cultivate the Minds of the Pupils, in all those Branches of Erudition, which are generally taught in the University abroad; and to perfect Their Design, Their next Care was to rectify the Heart, by inculcating the great Precepts of Christianity, in order to make them good Men."

It seems to me that this statement, in spite of its quaint phraseology, expresses the object of our educational endeavor as well as we can express it today. We need men who are professionally expert and technically skilled, but we also need men of character who possess knowledge and wisdom as well as expertness and skill. As the President of one of the great Eastern Universities said recently, "what we need is not narrow men trained in a groove, but broad men sharpened to a point."

Missouri Section.—The second annual meeting of the Missouri section of the Society for the Promotion of Engineering Education was held in Rolla on January 6 and 7. The meeting was called to order, following a dinner at the Sinclair Pennant Tavern, by Dean A. S. Langsdorf of Washington University, president of the Missouri Section.

Dean Langsdorf, in opening the meeting, stated that the initial meeting of last year was in the nature of an experiment, and expressed gratification that the present meeting, at which fifty-seven were present, showed an attendance of more than twice the number attending the initial meeting. Dean Langsdorf stated that many of the problems facing engineering educators today are problems common to all, and the exchange of information brought about at these meetings is beneficial to all concerned in the matter of engineering education. Dean Langsdorf introduced Dr. Charles H. Fulton, Director of the School of Mines and Metallurgy, as the initial speaker on the program. Dr. Fulton, after a few gracious words of welcome to the visitors, presented a paper on "The Gifted Student Program at the School of Mines and Metallurgy." Follow-

ing Dr. Felton's paper, Dean Langsdorf introduced Dean R. A. Seaton of Kansas State College, international president of the Society for the Promotion of Engineering Education. Dean Seaton, speaking of the S. P. E. E., stated that it is an organization to which everyone engaged in engineering education in any capacity, any-



where in the world, might well belong. Dean Seaton reviewed the growth of the various sections of the organization, the first one—the Kansas-Nebraska Section—being organized in 1920. "The growth of the sections has been rapid within the last few years, until now between two-thirds, or possibly three-fourths, of the members of the Society are also members of sections." These sectional meetings,

Dean Seaton stated, are of great importance and benefit to the membership, as they bring to their members first-hand information and the benefits of the meetings and discussions such as take place in the national meetings. Dean Seaton then presented a paper entitled "Post Graduate Study in Engineering."

Dean Langsdorf next introduced Profesor John P. Nafe, Professor of Psychology of Washington University, who, continuing the idea of the training of the gifted student, spoke on the matter of tests that might be given to detect the gifted student, and to give the gifted student greater opportunities for education development. Dr. Nafe stated that the problem of picking the student is becoming acute. "It is no longer a scholastic problem, but one of necessity," Dr. Nafe said. He reviewed the growth of the grade idea in teaching. There was a time, he said, when a student came to college and the faculty did not have to check up on him from day to day. He came for what he could get, but with the increase of the notion and the sale, or over-sale, of the idea of education, it is apparent that we very early in the day had to accept the system of giving grades. This involves a fundamental difficulty which educators may some day have to solve, and was the first effort to evaluate the work of a student. "One very great difficulty about the grade system, said Dr. Nafe, "is we get our information after the event rather than before it. What I want to talk about is the possibility of getting advance information on the students so that we can intelligently divide our students and select students for admission, or deny entrance to students, or eventually find the gifted students." Dr. Nafe stated that the idea began back in the 90's; that the general attitude was before the World War that, regardless of the progress that might have been made, the human mind was something that could not be measured. It was something hopelessly intangible and not capable of values as physical objects are. He then reviewed the progress of these measurements during the World War, the enthusiasm following, and then the reaction.

Dr. Nafe stated that the test so far developed have in mind three factors. The first is diagnostic; When the students get into trouble, could any test be given that would diagnose the nature of that trouble? He discussed the work that had been done along this line by Columbia University, started in 1898. The movement began with intelligence tests. These tests, in theory at least, do not attempt to measure what anyone has learned, but the potential capacity of the individual to learn. All of these tests deal with averages. But in dealing with averages, Dr. Nafe stated, there is no particular reason why we cannot deal with the fundamental capacities of any individual to learn or do any particular act. Dr. Nafe said that

there are certain difficulties in correlating general intelligence with performance in school. "We cannot expect to find a one-to-one correlation," he stated, "because all students do not fail college because of lack of ability, and some who lack ability can by superhuman efforts accomplish more than one with endowment. The first thing that is of interest between the I.Q. and college performance is the attitude of the student, and that is the most difficult thing to handle. We all know of the kind of student in college who, by some process of reasoning, believes that no successful man has ever gotten along in college. We find individuals who in some way feel that it is to their credit to be failed in college. We find other students whose attitude changes from day to day. At the present time we have only very poor measures of this particular factor in our correlation and have very little to suggest in the way of a remedy at the present time."

The next two great important factors, however, can be easily measured. The second one is the inability to read. The Iowa Silent Reading Test is a revelation to most faculty members who attempt to use it on their students. It is a very simple test. The student reads a paragraph and attempts to answer questions about the paragraph. The number of students entering college who cannot read an ordinary paragraph and know what that paragraph states is remarkable. Students with a sufficiently low I.Q. or sufficiently low score in intelligence test will not get through school. There is always a group on the ragged edge, which, by any standard test, we can discover and eliminate or give special treatment. But such a test as this reading test applies to those who can pass a relatively high test in general intelligence and still get into difficulty with their work.

The third and most important handicap, Dr. Nafe stated, is emotional stability. This thing is something that has been sensationalized and overdone also. He pointed out the difficulties of giving a particular test for emotional stability. These tests are often misunderstood by parents when the student goes home and repeats what is in the test and especially does the public misunderstand it, and it leads to serious consequence.

"The aptitude test," Dr. Nafe said, "is a test devised for the purpose of selecting out of a group of students the particular student who will make a good engineer, a good doctor, or a good lawyer." This kind of test has not been well worked out. "Like anything else," said Dr. Nafe, "the educators have arrived on schedule twenty years late. This idea has been used in industry for many years. There are stations for testing materials of all kind that are familiar to all engineers. Why we should have delayed so long in working out a test which shows men capable of taking a

technical education is something remarkable in this day and age. These tests are being worked on by various schools, but we have not been working on them long enough to have any very sure tests for any given profession. Perhaps we have worked too long on general intelligence tests. Perhaps we are starting a little too late on aptitude tests, unless the staffs now operating take these burdens upon themselves and work these things out. Such a thing should be possible—should be demanded. It can be done just as the measurement of general intelligence was done. Such a thing has possibilities and is worth working out to some sort of conclusion."

Following Dr. Nafe's talk, Dean Langsdorf appointed a nominating committee composed of Professor J. B. Butler, of the School of Mines and Metallurgy, Professor F. A. Berger, of Washington University, and Professor R. W. Selvidge, of the University of Missouri. The meeting adjourned for the day.

The section re-convened Saturday morning at ten o'clock in Parker Hall with Vice-president Rubey in the chair. The nominating committee presented their report, nominating the following for offices for the ensuing year: For President, Director Charles H. Fulton, School of Mines and Metallurgy; for Vice-president, Professor A. C. Lanier, of the University of Missouri; and for Secretary, Professor E. O. Sweetser, of Washington University. Upon motion the report was adopted and the candidates unanimously elected.

Dean Langsdorf presented a paper on "Science in Industry."

Professor F. W. Bubb, of Washington University, presented an informal talk on the subject of "Geometry and Some of its Ramifications." Professor Bubb stated that the space in which we live is not an academic subject. "It is a first requirement of all intelligent human beings that they comprehend something about the space in which they live." He traced the historical development of geometry through the early conceptions of the science down to the present conception of three dimensional geometry. Professor Bubb stated that there had been a deplorable tendency in recent years to shorten the time devoted to the science of descriptive geometry and to substitute for it work in drawing. The student's power to visualize and build up things in his head is the very essence of engineering work.

Following Professor Bubb's talk the section attended a luncheon at the Episcopal Parish House, after which a picture of the section was taken. At 1:15 the section re-convened in the Chemistry Building with Dean Langsdorf in the chair.

Professor Harry Rubey, of the University of Missouri, presented a paper entitled, "Trends in Engineering Enrollment and

in Demand for Graduates." In the discussion of his paper Professor Rubey stated that Professor Walter Rautenstrauch, from Columbia University, was in Columbia, Missouri, recently and gave to him a somewhat different slant on the technocrats than has been appearing in the press recently. Professor Rubey stated that most of the material they are getting together is not new, but they are getting it together in a little more complete form than has been done before. Most of the economic conclusions which have appeared in the press and in our magazines, so far as he could gather from Professor Rautenstrauch, are unauthorized by the group. They are merely the opinions of individual members—some with a flare for publicity and not to be taken too seriously.

Professor Rautenstrauch's individual opinion was that there has been a falling off in the rate of increase of production, beginning about 1920, in all commodities, and there has been a very great increase in the debt structure until it now represents 218 billion dollars. The carrying charge of this debt structure is so large that industry has been forced to reduce its pay rolls with the resulting technological unemployment. He stated that Professor Rautenstrauch felt that the present system be patched up for a while on the present basis, but in the course of the next few years somewhat radical changes must be made.

In the civil engineering field, Professor Rubey stated, their graduates for the past generation have been absorbed pretty much into the betterment type of work, and from there they gradually work into operations, but most of them went out to build and install new equipment. They were absorbed in the shaded portion of the diagram he showed, which from all indications is going to be a small percentage of our activities in the near future.

Professor Rubey stated that the engineering enrollment is about normal at the present time. Since the engineering enrollment follows business activities by a lag of a year or two, he stated we must expect another year or two of low registrations even if business does pick up, and it would not be out of all bounds of reason to expect a drop of twenty to thirty per cent in enrollment in the next year or two. He stated that the information available from the Land Grant colleges does not show serious decrease at the present time.

Professor Rubey thought that the engineer should have a fairly broad education since it seems impossible to predict where the graduate will go. Some will undoubtedly go into operations, and some into scientific pursuits. There will be fewer openings in betterment work in the future than in the immediate past.

Following Professor Rubey's talk a general discussion of the papers that had been presented at the session took place.

Dean Langsdorf stated that we are apt to lose our perspective and take a gloomy view of the present situation. "It is impossible to look very far into the future, but one thing that makes me feel that it is not so hopeless as many magazine articles seem to indicate is that there have been situations like this before, and it is not at all impossible that we will come out of this tail spin right side up. I don't remember very much about conditions in 1893, I have read about them, and about conditions in 1873 and 1837 or 38, and descriptions of all those times read identically the same as today Henry George's book, 'Progress and Poverty,' was written in 1873. If that were read to you now, you would take your oath that it was written by someone today. It is an absolutely valid picture of conditions today.

"It is not altogether right to assume that since conditions righted themselves after those trials they are going to do so again. We are in the position of the ancients who saw the sun going lower and lower and were in deadly fear that darkness was going to prevail. It is only in the course of time and through better knowledge of the laws of nature that we know that the sun is going to come back after the winter solstice. Maybe this is the winter solstice, and inherent in the nature of things. I doubt this. Conditions under which we are suffering are not the laws of nature. They are man-made conditions, and if that is granted, they are susceptible to change.

"When we look back over the history of this country and the depressions that have existed, we find rather interesting things to consider that brought about resumption. Following the panic in 1873, there was a long period of depression. We generally center on that year because of outstanding events like 'Black Friday' brought about by the speculations of Jay Gould. We find that this depression ended by a tremendous spurt of business activity which owed its impetus to the railway building in the eighties. The energies of the nation went into railway building, then into power house building, street railway building and everything that went into that sort of thing. Then when those petered out, following the panic of 1893, the automobile came in and took the energies and investment of the country. That has now reached the saturation point, and has failed us except insofar as automobiles are built for replacement purposes.

"It is not more than fifteen years ago, when everybody thought there was no end to the automobile, and no such thing thought of as the saturation point, that a Boston banker made an investigation as to whether or not there was such a limit, with reference to the wisdom of banks putting more and more money into automobile plants. I remember reading the report at the time. It was the

first logical analysis I had seen of that particular business. He went at it by the study of the census statistics of the government and divided the population into age groups. He reasoned that so many people were over 21 years of age and so many people under 65 years of age. In general only those in the 21 to 65 group would be in an economic situation to purchase automobiles. Since these were half men and half women, and women on the average should be wives, he divided that figure by two. Then he ruled out certain groups as not economically able to buy. He ruled out certain other groups for good and sufficient reasons and came to the conclusion that something like 22 million people were potential purchasers of automobiles, and allowing for the average life of the automobile at from five to six years, the country could economically use but something over four million automobiles annually. These predictions have been verified. That sort of analysis has not been made for any other line of business, and it ought to be made.

"As to the question of what can absorb the activities of the people in the present situation, there is only one thing I can see on the horizon. It has been mentioned by a number of writers during the last few years. My experience with the City Plan Commission makes me think it is the right idea. It is the rehabilitation of the housing facilities of the nation. That item alone, if it were put on a definite basis, would spell the immediate resumption of business activities in all lines. I think that is the outlet that is going to offer the hope in the next generation, and it may stall off any calamity that may loom up. What will come after that, no one can tell, and it is not worth while to predict twenty years in advance.

"A very large percentage of all the houses in the United States are not fit to be lived in. Go to East St. Louis, to Pittsburgh, or any large city—see their slums in their awfulness, and the disgraceful places in which people are forced to live. That is one way out of this depression. Coupled with this must be a realization on the part of business leaders that there cannot be a continuance of the array of exorbitant profits which go into investments for factories for turning out goods which cannot be absorbed. There must be something in the nature of an economic council for determining the convenience and necessity of these new factories. There are more coal mines, shoe factories, oil wells, and many other things than we need. There is only one answer. If you take those figures I had on the board this morning, which showed a maximum income in 1928 and 1929 of ninety billion dollars, we know pretty well that at least 80 per cent of the people had an income of 1500 dollars or less. If the income of ninety billion dollars is divided among thirty million people, and eight per cent or 24 million had an

income of $1500, that accounts for 36 billion. The difference between this and 90 billions must have gone into fixed investments. We ask that they do not invest so much and pay out more in wages that can go out in goods. It is just like a traffic jam or a dry season in which all of our springs are drying up. Perhaps we ought to pray for rain."

I should like to have the views of our newly elected president on these matters.

Director Fulton: I am returning to basic principles for my point of view on some of these things. I'll admit they haven't any bearing on some of the things we have been discussing and they solve no problem, but they lead me to be hopeful.

Looking back over past history, mankind has always gotten along very well and has improved his position. Today he is so far ahead of anything he has ever achieved that it seems to me there is no particular cause of alarm. We may be on the verge of a changing of a social system. I am not pink or red or any other color on that matter. Such a thing has happened before in human history.

Still dealing with fundamentals, I note when I go out to camp in South Dakota, where I go each summer, and look around I see the free air and the sun on the mountains. There are certain other animals that are there and alive. The squirrel, for instance, busies himself eating mushrooms and gathering acorn nuts and storing them. He, also, has an instinct for gain and accumulation. These instincts are fundamental in man. He is never going to get over that. Never can I conceive that man, acting socially, is going to give up his individual rights to save and accumulate all that his fellow man will permit him to get.

I think, based on that, with the fact that now we have more than we seem to be able to dispose of—we may not have that all the time but we certainly do now—we are facing a period where we are going to work out in a Democracy—most painful I will admit—some system of more equitable distribution of our own material goods. That operation is not going to be painless and it is going to be somewhat lengthy, but viewed as a whole from the angle of man and government, there isn't a problem in it that is insoluble or even over-ordinarily difficult. I think that if you faced a lack of facilities to produce goods and faced absolute poverty the situation would be alarming; but it is the contrary. It is a problem of distribution.

In dealing with natural laws the physicist examines his material and finally decides that, from previous knowledge, you can do something or you can't do it. We can decide whether or not the thing is possible or impossible, seemingly. So when you come into this domain of economics, on cool reflection it seems to me there

is nothing in that problem but what can be solved over a period of time with increasing happiness for all concerned. The situation is far from hopeless. I think it is the most hopeful thing that man has faced in a generation in what he is facing today. I think it is the solution of a problem.

I see mentioned the difficulties of solution and planning in a Democracy. That is a generalized statement, and the United States is not a Democracy in the ordinary old conception of the word. Back in the days of the World War this country was organized almost over night into a unit to solve a problem. At that time we all thought we were threatened by a great danger. Now if we could all feel that we are threatened with the great danger then I believe we could solve this problem in a relatively short time.

Please bear in mind I didn't get up here to solve any economic problem. I may have talked in generalities, but I ask has anybody in the last two years said anything else but generalities on this situation? Let me just leave a hopeful note with you. I think that engineers and technocrats, and such, are perhaps the people most able to offer solutions and help in the problem before the people.

Dean Langsdorf: I should like to have a discussion of what has just been said, and what it will mean to us engaged in educational work. I think we can expect a further shrinkage of registrations. I think we can expect a further shrinkage of income with which the educational work is carried on. That seems to be as definite as anything can be for the immediate future. What is the program the educational administrators will have to formulate in meeting this situation?

Director Fulton: I think that question is involved in the general matter of education. Is engineering education attendance tied up with any other forms of collegiate education or isn't it? Are we dealing possibly with a change of interest on the part of the people who send their children to school or are they not going to send as many children to school? Medical education, as you note, is tending to be restricted. The doctors are concerned about the production of too many doctors. Engineers and industry are concerned about the production of too many engineers. You will find the same thing in law and in business schools. The question then resolves itself as to whether or not the engineering attendance is going to decrease in greater proportions, due to lack of absorption into industry, than are the other college fields.

For example, will a man who has intended to send his son to an engineering school and make an engineer out of him—is he going to give up education entirely or is he going to send him to some other kind of school? I think that is the fundamental concept we are dealing with. I believe there is abroad in the public mind a

different concept about engineering education, and if you read the recent pamphlet—"Engineering—A Career, A Culture," just issued by the United Engineering Societies you will find in that, coming as it does from the profession as the deliberate expression of the engineering profession that engineering education fits a man for almost any kind of life work. Please note that I am not arguing that for your benefit, for engineering attendance, I merely state that this is a fact from that particular pamphlet. Now do we believe that is true or don't we? Even that doesn't make any difference. On that score you are having before the public today a different conception of engineering education—that it is a type of education which prepares and fits an individual better for facing life than a general education or a business training. Remember, we are dealing with education at the collegiate level.

I don't believe that in any sense can we arrive at an estimate of enrollment in engineering colleges by business at any particular moment. We have distinctive curve drawers here at the School of Mines—Professor Armsby and Dr. Mann and we have others—but even at that I am extremely suspicious of their collective efforts on anything of that kind. I believe that, of course, we are going to have conditions in industry that will give a falling off in attendance. I believe on the other hand education as a whole on the collegiate level is not going to decrease very largely in percentage in the United States. That means then if engineering enrollment is going to sink to lower levels these boys will go into other fields. I think they will stay in engineering. I think there is a concept among the people at large that engineering offers a general type of education, and I believe from that angle we might even have an increment. I would rather say that the level of enrollment, while it will fall somewhat, it will not decrease very greatly. What will happen if this continues four or five years longer I cannot say.

Professor R. V. Kilpatrick asked the question as to whether or not we are valuing education too much at the present time on some such basis as this: that education, unless it pays immediately or in the immediate future, is a failure. He stated that he tried to tell his students that the encouraging factor is that education is an asset that lasts through life.

Professor Selvidge: "What are we going to do about it if we have more students? Are we going to continue with them as we have in the past, or are we going to undertake to give them a little different training or philosophy in life and economics? I fear we have shown some tendency to lose our heads over the present situation just as in the past during panic periods. We run off after strange gods and finally come around to a point of sanity.

We have too many men in important positions little taken with

the idea that we must get back to a maximum again in our methods of production. It seems to me that the fundamental business of our activities is to supply human wants. It should be our purpose to supply these just as economically as we can. Human welfare is determined very largely by the degree to which we do supply felt human wants. We say we are not getting along well as there are many people who feel serious wants they cannot supply. I would like to see the relationship between the curve of human wants and the curve of production. It strikes me that in general as the curve of production goes down the curve of unsatisfied human wants goes up; that they do not tend to meet. There might be some significance in that if the people who are considering the advisability of less economical methods of production should make a study of those curves."

"I realize that many of our difficulties arise out of the fact that we make one or two curves and assume they are the only factors in the situation, when there are many.

"One of the difficulties in engineering training and practice lies in the fact that we assume that the job of the engineer ceases as soon as the product is put into form or shape, just as some of the farmers feel that when they get their crop made they can leave it in the field until it rots. They have done their production job. The engineer tends to the same thing. When he gets the article formed, he stops. As a matter of fact, production is not complete until the product gets into the hands of the consumer. I think that means that we should extend our training of the engineer not just to form the product but to keep on until he gets it into the hands of the consumer. Unless we put some engineering plans into this phase of production, I am afraid we shall continue with our present troubles.

"While we may say that the engineer is engaged primarily in production, we must not limit that idea of production, but make it into production *and* distribution. We are interested in producing this thing and carrying it through until it gets into the hands of the consumer. This means something more than the mere technical training we have given the engineer. We must train him to continue this process of production until the article is in the hands of the consumer. This is somewhat of a different kind of training than we have carried on before. We say that is business and belongs to the schools of commerce, but I believe that one of the most able methods of curing the situation so far as the training of engineers is concerned is through the training of the engineer to place the product economically in the hands of the consumer."

"Here I wish to offer a definition of 'technocracy.' I'm sure you haven't heard it before. Technocracy is a scientific bug com-

posed of economic sophistry, a faker's flare for publicity, Dr. Brinkley's scientific accuracy, and an atmosphere of engineering used as a catalyst."

Dr. Dake: "It occurs to me as I have listened to the discussion today that after all we as individuals here can play an extremely small part in settling the kinds of problems we have discussed. Things are going to work out over a long period of time. But this same problem raises for us a problem which is in our field and to which we as individuals should direct very clearly our efforts. That was indicated in the remarks just preceding in the expression that we are going to have to give our students different training to fit them to face new conditions they are going to have to face in the next few years. They say we as engineering teachers have done very little to try and accomplish that.

"One of the difficulties, of course, might be illustrated in this way: If any one of you were to try to pick out of the curriculum of any engineering college what was not essential to that curriculum you would be rather seriously puzzled to find what to take out to put in the kind of training that we feel these men ought to have. In other words, there is very little in there but what is essential to modern engineering training. It seems to me that the time has come when the engineering profession at large ought to attack that kind of problem in the same way that the medical profession has attacked their problem; that we have got to the point where we cannot give the kind of engineering training plus the kind of training that must go into engineering education in a four-year course, and that the thing that must be done is for this Society and for the engineering societies to sponsor a movement to go over to an enlarged course in engineering in which there will be a pre-engineering course that will devote itself primarily to the type of courses that will give the men training in the economic and administrative difficulties that they are going to have to face, and then top that off with their technical training.

"It seems to me that the engineering profession is going to have to face that if they are going to turn out into the world the kind of man who can take his part in the world affairs that he should. It is obvious that no one school can effect a course of that sort by itself. We have an illustration in the United States of a school of engineering which tried that and which found it a sorry failure. If it is to be done at all, it ought to be done with the backing and sanction of the engineering profession at large, the engineering societies, and the Society for the Promotion of Engineering Education. It must be carried on more or less along the same lines through all the educational institutions of the country. I believe we have arrived where it is essential that some such step be taken

because our graduates are going out without adequate foundation."

Professor Selvidge: "I will tell you what to take out of the curriculum—what the other fellow teaches."

Professor Lanier: "It seems to me that one of the strong things in the present undergraduate engineering training—and I have heard a number of men in the arts colleges, particularly in the science field, make the same statement—is the very thorough and definitely directed training in the physical science and the mathematical tools used with it, including the mathematical point of view. Insofar as the back-ground of professional training following this preliminary training is concerned, recent progress in industry has made very great changes in productions methods in which not only the machine production but the control is largely furnished through power. Production methods are largely controlled automatically and these changes in the production method have resulted in changes in design of product. The sorts of skills required of the operative or mechanic are very considerably changed. I think the value, as background material for design and other professional courses, of courses in shop practice, even when modified may be open to considerable question. There is a possibility here for economy of time in the curriculum, allowing substitution of other matter which may be more valuable.

"There is another place where I think there is a possibility of both improvement and economy in time. All of our professional courses and text books have been written on a practitioner basis. We have repeated certain methods of attack, using certain fundamental principles in each practitioner field. If we change that method a little bit, developing these general engineering principles and methods of attack, and drawing from the practitioner fields as illustrative material, it seems to me that there is possibility of considerable economy of time and of improvement in the subject matter courses. The student so trained becomes a thinker in the application of these methods to any problem. I believe it is not so serious a problem when we get down to it to find even in the four-year curriculum some place for the introduction of new points of view and the introduction of some economics of engineering in the several engineering curricula."

Professor Upson: "I agree with what Dean Langsdorf said on that housing proposition. I spent considerable time trying to find where there is an outlet for this situation we are in and I find that is the direction, but the people who control that situation have not yet wakened up at all, and as I say that is the great possible outlet.

"We should not get too much alarmed about things. We have been in depressions in the past and we will come out of the de-

pression as in the past. We have had more normal conditions in the world than we have had depressions. The fact may be that we are on the brink of a revolution of some kind which may not be apparent to us. One reason we come to a brink and go over unprepared is that we console ourselves with the idea that things will come out all right. I think that point should be brought out in this connection. I have talked to some of our economists and they tell me there are points of difference between this depression and depressions of the past. As I look over this crowd here I might think you the most contented group of men that might be found in the United States. Take those big capitalists of industry and you will find they have a lot more to worry about than we have. If we want to find out something about the extent of this depression and what the forces are that might result in an upheaval, we ought to get into another crowd. I feel that we should not lure ourselves into too secure a feeling of confidence that things will come out all right.

"Now as to the economic side of running our engineering schools, I am not quite sure how it is in the state university, but in endowed universities they depend on tuition. I think we might conclude that the senior class is more expensive than the freshman class, but I think probably the reverse is the case. Our freshman class has to have rooms like this, while the senior class gets along with smaller rooms. Building space and instructors are more the result of the freshman class than the senior class. I am not sure, but I think this may be the case.

"If we consider the product of the engineering school—and what we usually point to is our figures, as Professor Armsby would do—it would be those who have come clear through the four years and graduated. That is what we want to see, and we look with a feeling of disparagement at the large number of students who drop out during and at the end of the freshman year. We may say that the freshman year is such that that is part of our contribution, but after all it is a certain loss. At least we feel that it is a loss that the university suffers in the men who drop out before they have really gotten anywhere. If that is the case, then we are spending a lot of money on those who drop out. Then if that were true, we could say that really we are spending a lot more money on those who don't come through, and on that basis the freshman class is the most expensive.

"If we consider our students from their economic standpoint, I don't know how it is in Rolla, but in Washington we have boys that come from around there who have to scrape pretty hard for their living. One of our alumni suggested that we have our students do work in summer time that would help their pocketbooks and

give them experience. I prepared a list that showed that every single student had been working in summer. That is the kind of men that we get to a very large extent in engineering. Those boys who go into engineering are most generally boys who come from relatively poor homes.

"How would it be, with those two things in mind, if we had a sliding scale—if our freshmen had to pay the biggest tuition, or perhaps the freshmen and sophomores. Oftentimes the family would be able to scrape up the money for the first year and that would throw a large amount of money into our treasury. Then if the boy went on, he might find that his expenses decreased until in the senior year he might have very moderate tuition, or possibly none at all. Then in the fifth year he found his tuition was very low, or so low that it would encourage him to go on. Suppose then in the next year we actually paid him something and he acted as some kind of an assistant. We could then pick out these fellows and carry them along through the sixth year and possibly the seventh year. We could thus train up teachers for engineering and get better prepared teachers than we now get.

"The five year engineering course has always been a failure, very largely for the reason we have shaped our curriculum as we have. We have taken two years and tried to soak these students with preliminaries. This applies to what Professor Bubb said about advanced work in geometry this morning. I believe that our students would lap it up if they were far enough along to appreciate it, but what do we do? We give them some of those advanced courses in their unfinished condition, and the only way I can see is to switch things around a little bit. If I were able to do it, I would be glad to cooperate with Professor Bubb—even if necessary to put some of our electrical engineering into the sophomore year, and let him take the junior year with something or other. The electrical engineering is elementary stuff, and it seems to me that some of the elementary things could be shoved along. Perhaps we could do some shifting there that would be to our mutual advantage. I think Professor Bubb's position is sound except for that one practical reason; I don't think it would be fitted to sophomores."

Professor Bubb: "As a matter of fact, I was talking about the most elementary geometry. I left unsaid many things that I could not make clear. I thought we ought to have more courses in geometry.

"I am interested in these economic discussions and I find a uniform lack, in my conversations with all sorts of men, of any definite proposal of what to do. Everyone looks upon it as the activities of a great machine, economic, social, and cultural. I cannot help

but feel that it is a sort of alien monster. It is thinking its own thoughts, going its own way, and may be doing that in a perfectly safe way, but it is certainly not doing it in any sense that is intelligent to an average human being. The engineer is facing a very definite question. If it is permissible to liken it to a living organism, what are the brains of that organism? Are engineers the hands, or the individuals who make things, or can they aspire to be the brains of it? He has solved the problems of production and the physical side of distribution. There are some very obvious things that conspire to keep him from completing the circle. A man cannot buy something that he has not the money to buy. Some say the lawyers are one of the things in the way. I am beginning to question that. The engineers are the hired men of the financial interests, and they are certainly running things in the sense that they are directing intelligence; and is there any reason, legal or physical, why we should not take unto ourselves the position of putting the brains into the organism and declaring that we are as self-respecting as the lawyers are? They think they are endowed by the Almighty for the conduct of human affairs to be placed in their hands. I think they make a great mess of it.

"I have debated this question of technocracy. I have tried to find out what it is. As to what it constitutes and what it is likely to portend, I do not know. I suspect some of my friends have been reading the leading editorials in the newspapers. If this technocracy movement in any sense of the word means that the engineer is going to consider himself the brains of the organism, I am for it. I believe we might all of us study what technocracy is with a a view to possibly doing something to complete the job."

Professor Rubey: "Profesor Rautenstrauch told us that they are hoping to publish some material in the spring, but until that time we will probably not get very much other than the garbled accounts we have been getting from the newspapers and periodicals."

Dean Langsdorf: "There is one thing which Mr. Scott said and which Professor Rautenstrauch amplified at Atlantic City, namely, that the basis of income they recommend should be based upon an energy unit. Scott, in that article of his, talks about it indiscriminately as kilowatts, foot pounds, and other factors that would befuddle a man who had not studied physics."

Professor Selvidge: "Why not call it 'man hour' "?

Dean Langsdorf: "That is just the point. He at one point said that all political and social theory, from Plato to Karl Marx, must be rejected as evidence of dementia praecox. He does not seem to know that Marx was the originator of the man hour. The thing that is wrong with the philosophy they have announced

through Scott, and others like him, they maintain that the unit of measurement is the only thing—they leave entirely out of the picture all of those human activities that are not concerned with the foot pound, etc. If the basis of income is to be the energy that a man is the agent of liberating for productive purposes, then the Shakespeares, Platos, and Leonardo da Vincis, and all our great men like these, would starve to death immediately.

"I don't mean that this man Scott represents the group. There must be something else that they are holding in reserve, and therefore I am withholding judgment of technocracy. Their very name would indicate that they are aspiring to leadership by the rule of technology, and perhaps they may discover some wisdom that has not yet come out.

"I agree with what Professor Selvidge said—that if engineers are going to aspire to that kind of leadership, they are going to have to have different training to what they have now, and it certainly cannot be done in four years. You cannot expect a boy twenty-one years of age to have had the experience and contacts with life that would enable him to know what it is all about even if you tell him. I think there must be some sort of a continuation school for engineers.

"The problem though, is a very real one for all schools, and they are going to have to take some measure for meeting the situation. We are going to take it in the form, I fear, of an increase of teaching load in order to fit the coat to the cloth we have. It is going to mean a still further reduction in salaries. I cannot see any escape from that in the future, and it is an ideal opportunity for educational institutions all over this country to shake off dead wood, and I don't know of any institutions that haven't got some."

Professor Lanier moved a vote of thanks to the School of Mines as the host institution, which motion was seconded by Professor Koenig and passed unanimously.

Meeting adjourned at 3:30 P.M.

ATTENDANCE RECORD

Name	*School*	*Dept.*	*Title*
Seaton, R. A.	K. S. C.	Engineering	Dean
Langsdorf, A. S.	Wash. U.	Engr. & Architecture	Dean
Boll, K. R.	"	Chem. Engr.	Assoc. Prof.
Sweetser, E. O.	"	Civil Engr.	Prof.
Derby, F. H.	"	" "	Asst. Prof.
Wheeler, W. H.	"	" "	Asst. Prof.
Upson, W. L.	"	Elect. Engr.	Prof.
Webb, R. T.	"	" "	
Dunn, T. F.	"	English	Instructor.
Bubb, F. W.	"	Applied Math	Prof.
Siroky, Edmond	"	" "	Assoc. Prof.
Brick, B. R.	"	" "	Instructor.

Grumann, H. R.	Wash. U.	Mathematics	Asst. Prof.
Middlemiss, R. R.	"	"	
Ohle, E. L.	"	Mechan. Engr.	Prof.
Berger, F. A.	"	" "	Prof.
Koenig, L. R.	"	" "	Asst. Prof.
Kuenzel, H.	"	" "	Instructor.
Sager, E. H.	"	" "	Instructor.
Butler, Col. H. L.	"	M. S. T.	Prof.
Nafe, John P.	"	Psychology	Prof.
Wooley, J. C.	Mo. U.	Agri. Engr.	Prof.
Jones, M. M.	"	" "	Assoc. Prof.
Smith, D. D.	"	" "	Instructor.
Parlson, P. P.	"	" "	Instructor.
Calvert, S.	"	Chem. Engr.	Prof.
Schlundt, H.	"	Phys. Chem.	Prof.
Lorah, J. R.	"	Chem. Engr.	Assoc. Prof.
Wintertown, H.	"	" "	
Rubey, Harry	"	Civil Engr.	Prof.
Weinbach, M. P.	"	Elect. Engr.	Prof.
Lanier, C. C.	"	" "	Prof.
Wallis, C. M.	"	" "	Instructor.
Selvidge, R. W.	"	Mech. Engr.	Prof.
Phillips, Ed.	"	" "	Prof.
Gray, E. S.	"	" "	Assoc. Prof.
Wood, H. W., Jr.	"	Mechanics	Assoc. Prof.
Reese, H. M.	"	Physics	Prof.
Dufford, R. T.	"	"	Asst. Prof.
Hammond, H. E.	"	"	Asst. Prof.
Fulton, C. H.	M. S. M.		Director
Armsby, H. H.	"		Registrar & Student Adv.
Hubbard, N.	"		Asst. Registrar
Dodd, C. M.	"	Ceramics	Assoc. Prof.
Schrenk, W. T.	"	Chem. Engr.	Prof.
Dunlap, H. L.	"	Org. Chem.	Prof.
Monroe, C. J.	"	Chemistry	Assoc. Prof.
Butler, J. B.	"	Civil Engr.	Prof.
Bardsley, C. E.	"	Hwy. "	Prof.
Carlton, E. W.	"	Civil Engr.	Assoc. Prof.
Ahrens, H. E.	"	" "	Asst. Prof.
Decker, E. E.	"	" "	Instructor.
Mann, C. V.	"	Engr. Drawing	Prof.
Frame, F. H.	"	Elect. Engr.	Prof.
Lovett, I. H.	"	" "	Prof.
Ranes, G. O.	"	" "	Assoc. Prof.
Barley, J. W.	"	English	Prof.
Bradley, S. P.	"	"	Asst. Prof.
Cagg, M. H.	"	"	Asst. Prof.
Dake, C. L.	"	Geology	Prof.
Grawe, O. R.	"	"	Asst. Prof.
Dennie, F. E.	"	Mathematics	Assoc. Prof.
Goodhue, E. A.	"	"	Asst. Prof.
Miles, A. J.	"	"	Instructor
Kilpatrick, A. V.	"	Mechan. Engr.	Assoc. Prof.
Hanley, H. R.	"	Metallurgy	Prof.
Steinmesch, J. H.	"	Mining	Prof.
Stephenson, E. A.	"	Pet. Engr.	Prof.
Woodman, L. E.	"	Physics	Prof.
Ratliff, R. F.	"	"	Assoc. Prof.
Jensen, W. A.	"	"	Assoc. Prof.
Willson, J. M.	"	"	Instructor
Thomas, C. D.	"	"	Instructor

Beckman, H. C.	State Geological Survey
Bolon, H. C.	" " "
Jennings, C. H.	" " "
Coghill, W. W.	Miss. Valley Expr. Sta. of Bureau of Mines
Lewis, B. P.	Supt. of Rolla Public Schools

Summary of Attendance

Kansas State College	1
Univ. of Mo	19
Wash. Univ.	20
Mo. School of Mines	33
Mo. Geol. Survey	3
U. S. Bureau of Mines	1
Rolla School System	1
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Newark College of Engineering Branch.—On February 10, twenty-six members and guests of the Newark College of Engineering Branch of the Society for the Promotion of Engineering Education met in Thomas' Restaurant, Newark, to discuss Eaton's "College Teaching."

The discussion was preceded by a luncheon and a short business meeting and then it was turned over to Professor J. Ansel Brooks, Head of the Mechanical Engineering Department, who had volunteered to lead the discussion. The subject was first suggested by Chairman Entwisle who had read the book and derived considerable benefit from its contents.

Professor Brooks introduced the subject matter by briefly outlining Professor Judd's thoughts on the subject: viz., that teaching should not be standardized; that teaching could be divided into three parts—subject, teacher and student, and learning could be subdivided into effect, exercise and readiness. He then offered for discussion a series of questions which had suggested themselves to him in his reading of Eaton's book. The questions follow closely the outline which Professor Entwisle had prepared.

Professor Brooks was very successful in creating lively discussion of every question submitted. The members and guests seemed to enjoy a meeting of this type and it is contemplated to have a similar one sometime in April.

The **Pacific Southwest Section** held its first meeting in the Atheneum Club of the California Institute of Technology at Pasadena on December 29, 30 and 31.

The first session opened with the adoption of the constitution and the election of officers for the year 1933. This was followed by a paper by Professor Franklin Thomas, of the California Institute of Technology, on the history, aims and activities of the Institute, and a paper by Professor R. W. Sorensen, of the Institute, on the

correct length of engineering courses, including graduate work, and the degrees awarded therefor.

The opening session was held on the afternoon of the first day. Mr. Allan C. Balch, co-donor with Mrs. Balch of the Atheneum Club building, gave the address of welcome, which was responded to by Dean Seaton, President of the Society. Dean and Mrs. Seaton had come especially to the coast, to show his interest and that of the Society in the formation of the new Section. Professor R. L. Daugherty, of the California Institute of Technology, delivered a paper on engineers in government and civil relations, after which Professor Sorensen conducted the visiting members on a tour of the various laboratories, libraries and lecture rooms of the Institute. In the evening, an informal reception and dinner at the Atheneum Club were enjoyed by the members and the ladies.

At the third session, on the morning of the second day, the following papers were presented:

"Visual vs. Aural Education," Professor F. H. Cherry, University of California.

"Shop Courses at California," Professor N. F. Ward, University of California.

"Combined Course in Engineering Materials and Strength of Materials," Professor Gilbert H. Dunstan, University of Southern California.

The afternoon of this day was devoted to excursions, some of the members visiting the Huntington Library in Pasadena, and others the Mt. Wilson Observatory, where they were shown the 100-inch telescope and, in the evening, were allowed to look through the 60-inch telescope.

The morning of the third day was devoted to the presentation of the following papers:

"Economic Status of the Engineer," Dean R. B. Ketchum, University of Utah.

"Administrative Recognition of Teaching Ability," Professor J. C. Clark, University of Arizona.

"Orientation for Engineering Freshmen," Professor Daniel E. Whelan, Loyola University.

"Coöperative Training in the Junior College," Mr. H. H. Bliss, Riverside Junior College.

The papers presented at the various sessions evoked a great deal of lively and enlightening discussion. An interesting feature of the meeting, in view of the magnitude of the junior college movement, in California especially, was the large number of junior college instructors who were present.

In addition to Dean Seaton, visiting members of the Society who attended the meeting of the Section were Professor A. W.

French and Professor Emeritus J. O. Phelan of Worcester Polytechnic Institute, and Professor V. L. Maleev of Oklahoma A. and M. College.

The University of Southern California, in Los Angeles, was selected as the place of the second meeting of the Section, in December, 1933.

The following officers were elected for the year 1933:

Chairman, H. B. Langille, University of California.
Vice Chairman, D. M. Wilson, University of Southern California.
Secretary-Treasurer, Franklin O. Rose, Modesto Junior College.
Additional Members of the Executive Committee, J. C. Clark, University of Arizona; A. B. Domonoske, Stanford University; R. B. Ketchum, University of Utah; Franklin Thomas, California Institute of Technology.

FRANKLIN O. ROSE,
Secretary-Treasurer.

The sixth annual meeting of the **South Dakota Section** was held in the Alonzo Ward Hotel at Aberdeen, January 12, 1933.

The morning meeting was called to order at nine o'clock by President E. E. Clarke. The minutes of the 1932 meeting were read and approved. President Clarke then appointed the following committees:

Nominating committee—Dean Crothers, Prof. Newcomb and Mr. Walkling.
Resolutions committee—Prof. Carter and Prof. Gamble.

At this time President Clarke asked the members to consider the advisability of a spring or fall meeting of the Section, rather than a winter meeting, this topic to be brought up later at the business meeting.

9:15—Professor Brookman, Vice-President, took the chair while President E. E. Clarke read his paper, "The Future of Engineering Education." Professor Clarke said he was not attempting to state the future of engineering education, but rather to raise some questions. How engineering teachers meet these questions will determine the future of engineering education.

The discussion was led by Professor Strate with a prepared paper, in which he raised some further questions that will have to be answered by engineering teachers. Following this, Professors Smith, Carter, Brookman, Deans Durland, Crothers, Mr. Lowe, Mr. Yost and Mr. Williams contributed to the discussion.

10:30—Professor H. B. Blodgett presented his paper on "Engineering Teaching Methods." Mr. Blodgett stated he believed that the problem of grading was closely allied to this topic, and concluded his paper by presenting a very interesting formula for use

in grading problem courses. This paper was discussed by Professor Clarke, Professor Brookman, Professor Smith and Mr. Williams.

11:10—As Professor J. Maughs Brown was unable to attend the meeting, his paper "The Engineering Graduate" was read by Professor Newcomb. Professor Brown from his experience in classroom and as head of the South Dakota Highway Commission contended that the schools cannot hope to turn out graduates to the specification of any practicing engineers or group of engineers, but if the schools can turn out graduates with such a foundation that the employer states, as they generally so proudly do, "He wasn't so good when I got him, but after working him over, he turned out to be a good engineer," the college has realized its aim.

Professor Brookman led in this discussion. Further comments were made by Mr. Aldrich and Mr. VanDyke. Dean Seaton answered Professor Newcomb's question concerning requiring the teaching of public speaking in Engineering schools by stating he thought about half of the engineering schools had a public speaking requirement. Dean Dolve added that he thought the public schools were taking over this training by giving the young people extra work along this line.

12:00—Recess for lunch. Arrangements had been made by Prof. Carter to have the group eat together in the dining room of the hotel.

Afternoon Session

1:35—The meeting was called to order by Professor Clarke.

1:40—Dean R. A. Seaton of Manhattan, Kansas, National President of S. P. E. E., presented his paper on the timely subject "Postgraduate Study in Engineering." Dean Seaton stated that it appeared the engineer had completely solved the problem of production, since we seem to have enough of everything. But the work of the engineer is constantly increasing in complexity. He suggested that another year or more of training would be highly desirable for perhaps 25 per cent of engineering graduates. He also stressed the desirability of engineering teachers having pursued postgraduate work leading to higher degrees. With the permission of the group, discussion of this paper was withheld until after the presentation of the paper "Graduate Students in Engineering in South Dakota" by Dean Crothers. Dean Crothers brought out that instruction in any advanced field should be based on a survey primarily of the men to guide or teach; secondarily, of the equipment in the laboratories and libraries. And to the extent that any institution has such men, the taking of an occasional graduate student for at least the early stages in his career should be of advantage to the student, the teacher, and the institution.

Professor Gottas was to have led the discussion, but as he was

unable to attend the meeting, Professor Brookman read his prepared discussion. Prof. Blodgett, Prof. Hoy, Prof. Smith, Dean R. A. Seaton and Dean Durland all added to the discussion. Dean Seaton suggested that if the industry did not hold the possession of a M. S. to be handicap, the M. S. had about the same status as a B. S. had a few years ago.

3:00—The business meeting opened with President Clarke in the chair. The nominating committee reported H. E. Brookman for president, Wm. H. Gamble for vice-president, C. G. Watson for secretary-treasurer. It was moved by Prof. Carter and seconded by Mr. Lowe that a unanimous ballot be cast for the nominees. Motion carried and ballot cast.

The resolutions committee presented the following resolutions:

1. Whereas: Dean R. A. Seaton, President of the National S. P. E. E. and Assistant Dean M. A. Durland, both of Kansas State College, have journeyed all the way from Manhattan, Kansas, to meet with us and to participate in this meeting by presenting an outstanding paper, and by adding their able discussions to the various papers.

Be it resolved: That we, the South Dakota section of the S. P. E. E. express to them our gratitude and appreciation for their interest in the welfare of our section as thus demonstrated.

2. Whereas: Dean R. M. Dolve and four of his engineering staff members have driven from Fargo, N. Dak. to participate in our meeting and enjoy Dean Seaton's paper and other papers of our program.

Be it resolved: That we express to them our appreciation for their joining us in welcoming Dean Seaton and in discussing with us the various papers presented here to-day.

3. Whereas: The Alonzo Ward Hotel of this city has extended to us the courtesies of its facilities.

Be it resolved: That we extend to them our thanks for these courtesies.

The financial report of the Section was read by the secretary-treasurer. Motion was made by Dr. Crothers and seconded by Professor Brookman that all members of the South Dakota section be levied an assessment of one dollar, the secretary to notify the absentees of this assessment.

The discussion of the change in time and place for future meetings followed. Dean Durland told of what they were doing at their annual meetings in his section. He suggested that possibly the wives of the members might enjoy attending; also, he added, they had found that the inclusion of a golf tournament or a football game added interest to their meeting. Dean Seaton, replying to the question concerning the relative size of our section, said that the

inclusion of North Dakota in our section would still leave it much smaller than any other sections.

He also mentioned the great advantage of meeting at the various institutions, in that a great number of the members are already in that institution, and will attend the meetings which are held there, and will thus become interested and soon attend the future meetings away from their own institutions. After further discussion, Dr. Crothers suggested a straw vote among the members present to see who would favor having the annual meetings of the S. P. E. E. held at the various institutions in rotation in the sections and to include the North Dakota schools. The straw vote indicated that everyone present was in favor of such a change. Dr. Crothers then made the motion, seconded by Professor Brookman, that the officers be authorized to act on this straw vote. Walkling moved the amendment to the above motion that the officers canvass the members of the South Dakota section. This amendment seconded by Prof. H. B. Blodgett, amendment and motion both carried. Mr. Walkling then moved that the officers extend an invitation to the North Dakota schools to join in forming a new section providing the members of the South Dakota section decide to change their meeting time from the present method of following the Engineers and Architects to that of meeting at the various institutions. This motion was seconded by Professor Blodgett. Mr. Lowe moved that the above motion be amended to read that we invite the North Dakota schools to join us in forming a new section, no matter when or where the meeting was held. Seconded by Prof. Strate. The amendment and motion both carried.

Dean Seaton then answered the question raised by Dr. Crothers concerning the procedure of establishing a new chapter, by stating that it was not necessary to get any permission from the National office, adding that it was a matter for the local group to decide.

Meeting adjourned 3:45.

WM. H. GAMBLE,
Secretary.

GRADUATE STUDY IN ENGINEERING FOR SOUTH DAKOTA

BY H. M. CROTHERS

South Dakota boys average high in native ability. The percentage who have the ability to profit by graduate study is probably as high as in any section of our country. And steadily a small percentage have been attracted into advanced work and have started this work either in our own schools or in adjoining states.

We have reason, therefore, to take part in any general discussion of graduate work, and to consider in particular what part we should take in providing that work for South Dakota Students. This paper will deal with both phases—that is, with some questions that pertain to graduate work in general, and some questions that pertain to South Dakota conditions in particular.

The nature of graduate work is a fundamental question. The progress report of the S. P. E. E. Committee to consider graduate work, given at the Corvallis meeting, and published in the October Journal, contains four paragraphs outlining views of the Committee on this question. The first two paragraphs read as follows:

"*The Nature of Graduate Study.*—It is believed that any discussion of graduate study will be more fruitful if some agreement can be reached as to the basic nature of graduate study, for in the opinion of your committee there is or should be a decided difference between undergraduate and graduate study. Undergraduate work on the part of the teacher is of the nature of *instruction,* and on the part of the student largely of the nature of acquiring as wide a knowledge of the field in which he works as time and ability will permit. For the most part both teacher and student are dealing with knowledge and facts already existent.

"Graduate study, on the other hand, should be primarily of the nature of research. On the part of the teacher it should consist of *guidance* and on the part of the student it should be, partially at least, a venture into the unknown. No graduate work worthy of the name can be conducted solely by class room methods, so far at least, as the major study is concerned. None but students with initiative should undertake graduate work; but with this initiative there must be complete mastery of the necessary fundamentals. Before research of any kind is attempted, a foundation of essential knowledge must be laid."

For such a condensed statement as above, it is difficult to be sure of all that the Committee had in mind. But in spite of the obvious presumption that is involved, the writer will do as one diplomat does with another in international affairs, *i.e.,* he will agree with the statement as offered and then explain at length just what he is agreeing to.

Certainly graduate study and graduate instruction should differ from our usual undergraduate work. It seems that we all should agree upon that as a principle. Probably we do. But we need to have it emphasized more, in such statements as this committee report. We need to have it adhered to more closely in practice. The path of least resistance is to let the graduate student operate in the manner he is accustomed to, rather than to accomplish the change that is implied.

How should graduate work be different? Are we clear in our minds and in agreement as to the changes that are implied? Possibly not, and if not, this question should be fruitful ground for discussion.

There are numerous ways in which the work of graduates may be and should be different. First as to the substance of the work, or the ground to be covered. The Committee report, as quoted, stipulates that graduate work should be primarily of the nature of research. Also that before research of any kind is attempted, a foundation of essential knowledge must be laid. The possibility of conflicting claims upon the student's time and efforts are apparent. We need to study carefully how these claims may be adjusted and harmonized, particularly so in work that is intended to lead only as far as the Master's degree.

There are in reality at least three different types of work commonly used to-day in varying proportions for advanced degrees. As tentative names we suggest the following: (*a*) broadening subjects, (*b*) advanced work, (*c*) investigative or research problems. These types are more easily illustrated than named or defined. The fact that sharp dividing lines do not exist between the classes, need not embarrass us greatly if the classification proves useful.

By broadening subjects is meant those subjects open to undergraduates, which a graduate student takes to broaden his foundation or his viewpoint. Work taken as minors commonly falls in this class. Or if a graduate student in electrical engineering were allowed to count elective subjects in elective railways, communication, illumination, or other applications of electricity which were open to him as a senior, but not taken then, such subjects must be justified as broadening subjects, rather than as advanced or research work. In Civil Engineering the undergraduate courses may provide for several options in structures, highways, railways, sanitation, water, power, etc. If a student pursues one or two of these for his baccalaureate degree and is allowed to count work in another towards an advanced degree, it can only be justified as broadening rather than as of the advanced type or the research type.

By the term "Advanced Work" is meant study in well established fields of knowledge that are rather beyond the reach of usual undergraduate courses, because of more critical attitude or more extensive foundation required. Any main branch of engineering has now rather extensive fields of this nature. Let the advanced fields in Mechanics be mentioned as possibly the oldest and most extensive. There is a wealth of material well established and carefully developed in hydrodynamics, aerodynamics, elasticity, vibrations, etc. And in Electrical Engineering there is the mathematical theory of electric networks as developed by Heaviside, Pupin, Ken-

nelly, Carson, and others. Both of these fields are generally considered beyond the reach of the average undergraduate course, yet much material is available in text book form if desired.

The two fields used as illustrations may be better organized than many others in which developments are available mainly in original papers. But each branch of engineering has more than one field in which developments have been carried well beyond the undergraduate courses. And for study in these fields, the term "advanced work" seems appropriate. And it is needless to say that this type of work is being used at present for graduate study.

The third class of graduate work we called the research or investigative type. Because of the wide range of meanings attached to the word "research," perhaps it would better suit our purposes here to use the less pretentious term "investigative." By the investigative type of work is meant the effort spent on questions or problems hitherto unanswered; in exploring conditions or relations hitherto unknown. It is generally expected that something of value may be added to the knowledge in that particular field by the investigation, but the extent or the value of this knowledge has never been specified by an accepted authority. From the standpoint of student training the acquaintance with investigative methods, the development of curiosity, initiative, resourcefulness, self-reliance, and a critical or questioning attitude seems of at least equal importance with any other consideration.

In current practice in the Graduate Schools, at least the thesis is expected to represent this type of work.

It is recognized that these three types of work are used to-day in varying proportions towards the Master's degree, which is of main interest to us in South Dakota. The S. P. E. E. Committee referred to, apparently accepts this situation. One of their explanatory comments in the Report reads as follows, "While no doubt course work may serve admirably for minor subjects, it would appear that no degree beyond the baccalaureate should be granted without some evidence of ability to do original work." We desire, of course, some notions as to how the three types of work may be combined—in what general proportions. But the discussion of this question is bound up with other differences which should exist between graduate and undergraduate work to which we will first turn our attention.

We have used as a "text" the statement of the Committee that graduate work should be primarily of the nature of research. Obviously the Committee was not proposing, and neither can we, that true research material be used exclusively throughout graduate work. The nature of research lies in research methods rather than in any set material. The methods with variations may serve re-

peatedly, while a research problem, once solved, ceases to be true research material.

The use of true research problems has the advantage of forcing the choosing or devising of methods to fit the problem. But to a graduate student many established fields are unknown fields. It is possible, of course, for him to ignore the discoveries of others until after he has conducted independent explorations of his own. The advantages of such a procedure, are the well known advantages of original independent work, the development of initiative and confidences that comes with experience. One of the disadvantages is the relative slowness of such procedure, as to the material covered. To cover known fields rapidly we not only make use of the discoveries of others, but teachers put unlimited time and effort in arranging these discoveries in the most logical and easily comprehended order, in reducing the original presentations to common terminologies and common notations. The methods devised to secure speed in mastering known fields are in almost direct contrast with the methods of original effort. So no one proposes seriously that in order to secure the benefits of original exploration, graduate students make entirely independent investigations of advanced fields.

But the belief is general that one of the prominent differences between graduate work and undergraduate work should be the extent to which relatively important features of the work are left to the independent effort of the student. As a general statement this is easy to agree to. When it comes to working out the details, perplexing questions arise, and probably no teacher feels competent to do more than offer suggestions based on his own experience.

To bring the question close to our conditions in this state let us consider a graduate student, candidate for a master's degree, with one of the branches of engineering as his major subject. In developing the advanced field in the major subject, certain complex theories of basic importance may be followed through step by step under detailed guidance of the teacher, in order to make the progress considered desirable. On the other hand other topics in the field may be briefly outlined and then left for the student to develop by his own efforts. Such topics should call forth independent analysis or investigation on the part of the student. Problems calling for the applications of the advanced principles, and on a scale much greater than in undergraduate work may serve this purpose. Mere magnitude is of course no criterion as to the suitability of a problem, the degree to which initiative and judgment are required should rather be the test. Occasionally corollaries of the main theory may be suitable for independent demonstration.

Certainly in the major field the student should be expected to

do considerable independent reading. The use of text books as in undergraduate work seems doubtful procedure. It may be advisable to use one author's presentation as a starting point in developing certain new topics, but that should not be the end. In his major field a graduate student should become acquainted with the presentations of several authors. He should make some comparisons of his own and select the forms or methods that seem most useful to him. At least during the work for a Master's degree he should show evidences of a start in this direction. The history of developments in the particular field he has chosen, estimates of the men who have developed, and are developing this field; these and similar matters may be matters of curiosity to be touched upon in the independent reading expected.

Lack of time will prevent fulfillment of all of these ends, or of more than one or two such ends during the preparation for the Master's degree. Independent reading habits may be hard for some students to form, but in the opinion of the writer they should be insisted upon—insisted upon not by periodic assignments, but by the understanding that in the final comprehensive examination for the degree, the student may be expected to discuss the objects and extent of his independent reading, must as he is expected to discuss his thesis investigation. Guidance by the teacher may well be only by consultation and discussion such as commonly given in the thesis investigation. More detailed guidance would defeat one important purpose of the work in the opinion of the writer.

The preceding paragraphs have referred, not to the thesis investigation, but to the work in the advanced topics of the major field. The possession of initiative and ability to do independent work is listed by the Committee as the essential characteristic of the graduate student. If this specification is commonly accepted, as it seems it should be, the topics left to the independent efforts of the student, either through original analysis or experiment, or by reading, should be such as to demonstrate and develop these qualities. It is recognized of course, that independent efforts require time, they are apt to be poorly directly at the start, methods of exploration must frequently follow trails to a blind end. To the extent we adopt independent efforts of the student in mastering established fields of knowledge, we sacrifice rapid progress. The actual balance between closely guided efforts of the class room type and other type of independent effort, in mastering an advanced field will be a compromise, differing probably for each teacher and each student.

The Committee apparently finds in its surveys, that too many such compromises result in the practical elimination of independent efforts. Whatever the desirable balance may be, this would seem not

to be it, if advanced degrees are to signify trained ability for independent work. The object of such discussions as this is to arrive at some more common agreement as to the significance of the various advanced degrees. It is conceivable of course that an advanced degree representing a year or more of additional work similar in character to undergraduate work, may be commonly desired. This paper, however, is based upon an opposite conclusion.

To apply the preceding discussion to our conditions in South Dakota is not so difficult as might be imagined. We recognize of course limitations of time and effort that we may put into graduate work, especially under present conditions. We recognize also the advantages of those new contacts and new viewpoints secured by migration of students for graduate work. At State College we advise our engineering students desiring graduate work to transfer to another school if possible. We also advise them that at present we are unable to devote sufficient time to graduate students so that a major subject in engineering may be completed in one year. But there are assistants or instructors and occasional students with other demands upon a part of their time, who are well qualified for, and who are interested in graduate work upon a part time basis. We deem it essential to the welfare of the department that at least this much work in advanced fields be in progress. It is needless to say we are looking forward to the return of conditions such that more active research programs may be undertaken.

The practice in providing programs for our occasional candidates for the Master's degree in engineering is in line with the preceding discussions. A student is not accepted as a candidate for a Master's degree unless his undergraduate record indicates ability to do independent work. One or two minor subjects may be taken, in which the work is mainly of the broadening type. It is stipulated, however, that graduate students must do some additional independent work to secure graduate credit in any class subject carried with undergraduate students. The major in an engineering department is expected to emphasize work of the advanced type and investigative type. Some subjects of the broadening type may be included in a major, provided only one minor is chosen. But approximately half of the total work submitted for the Master's degree is advanced work or investigative work under the major department. The advanced work usually extends over approximately two school years, there are seldom more than one or two graduate students in any advanced field, therefore, it becomes relatively easy to put emphasis upon the independent efforts of the students, and this is done.

The pure investigative type of work is commonly confined to the thesis, which represents about one-fifth of the total time or

effort, but in some cases much larger portions of the time have been spent in this type. A creditable showing in a comprehensive oral examination open to visitors is required. These policies and procedures are open to modification, either experimental or permanent, as we learn of other policies that may better fit our conditions. It is hoped that suggestions will be forthcoming.

One other question should be touched on briefly before closing this paper. There may be a question in the minds of some as to whether any graduate work at all should be given in engineering schools with only limited facilities. Occasionally statements are seen which appear to raise this question. But it appears there should be little question if a few general principles are applied with care.

In the first place any instruction, graduate or undergraduate, in any school, large or small, should be confined to the fields in which that school is prepared to render a real service to students. It is plain folly for a school with limited facilities in a few fields to attempt to offer extensive graduate programs in all advanced fields. Instruction offered in any advanced field should be based upon a survey; primarily of the men to guide or teach; secondarily of the equipment in laboratories and libraries.

Not all engineering teachers keep up an active interest in an advanced field. This is unfortunate but apparently true. Graduate instruction in any field should be in the hands of men who have kept up an active interest in that field and who are capable of guiding and stimulating graduate students in it. In fields where such men are not available, going through the motions of advanced study can accomplish little.

To the extent that any institution has such men, it would seem that taking an occasional graduate student for at least the early stages of his career should be of advantage to the student, the teacher, and even to the undergraduate instruction. Therefore, it has been assumed throughout this paper that each engineering school would feel prepared to accept occasional graduate students in selected fields.

OBSERVATIONS ON ENGINEERING TRAINING

By J. MAUGHS BROWN

University of South Dakota

It often has been said that every man has two sides to his character—one good—one bad, and that life for him is a constant war between the conflicting elements. Be that as it may, nearly all of us have had diverse and conflicting experiences that often leave

us puzzled as to what is best. After having contacted a question from two opposite sides we sometimes feel less sure of a correct answer than had we been looking at the picture entirely from one angle.

I presume I was asked to prepare this paper because of my experience as an engineer employing engineering graduates, and as an instructor preparing young men for the engineering profession. My own personal experience has been divided about equally in point of time between teaching and active engineering practice. I feel that I am qualified from the point of experience to at least discuss the question assigned me, but I am not at all sure that I have any observations that are at all noteworthy.

First, I am going to say that there is apparently a difference of opinion between the college professor and the practicing engineer as to what should be given the engineering student, both in the way of training and the material to be mastered. I am also inclined to believe this difference in opinion is more apparent than real. I have talked to many practicing engineers who were firmly convinced that there was something radically wrong with our usual college training. The engineering graduates whom they knew did not at once meet their requirements, and their complaint was they had to remodel them before they became very useful. They admit that after they have "remodeled them," as they say, the engineering graduates became very useful and competent engineers. These practical engineers pride themselves on their ability to remake and remodel our engineering graduates, and they feel that if they had the opportunity they could teach engineering students so they would not have to go through this working over after graduation. The woods are simply full of these practicing engineers who hold this opinion—their numbers are legion—but their opinions cannot be taken too seriously, and they sometimes exert a dangerous influence over engineering education. Their opinions may become dangerous when received by men who are responsible for outlining policy in engineering education, but who have not had enough actual experience in engineering practice or business contact with practical engineers to be able to properly evaluate their views. The opinions of these men certainly ought to be considered, and from time to time one receives some pertinent suggestions and some real help. But leaving out the valuable nuggets that happen along now and then the general run of the mine does not assay very high for the following reasons:

1. The average practicing engineer is engaged in a particular line of engineering and sees the graduate from his own restricted viewpoint only.

2. The average practicing engineer credits all his successes to

his own innate cleverness, and his failures to some defect in his college training.

3. The average engineer has not given much thought to engineering education. He has not taken the time to study and analyze the problem, and he does not see it as a whole.

4. While engineering instructors frequently hold divergent views as to methods and material, the points of difference are relatively few compared to the wide differences of opinion expressed by successful practicing engineers on engineering education.

5. The successful engineer's opinion cannot be taken at face value for very few can or will correctly analyze their own rise to prominence.

My experience as you know has been in the civil engineering field. I have found men in one specialized branch of civil engineering who would gladly write us a specification for use to follow in preparing men for them. Go over to the next firm or the next corporation engaged in almost exactly the same specialized branch of engineering and have them write out a specification to suit their ideas and the two would probably not agree in many important particulars. If we find this difference between men in the same specialized field, it is obviously impossible to try and satisfy the particular requirements of all of the many lines of engineering practice. To try and do this would shift the burden and expense of particular organization education from the industry where it rightfully belongs to the shoulders of the tax-payers and others where it does not belong.

Those of us engaged in teaching engineering have a duty to perform that we sometimes do not fully recognize. Besides teaching our students, we have to bring home to our friends and professional brothers in active practice that we are not trying to turn out graduates adapted to one thing only. What we aim to do is to turn out a first class "chassis." Our friends can take this chassis and "doll it up" as they see fit. They can make a fast passenger car out of it or a truck as their requirements demand. It is no little accomplishment if we hand them over a man they can work on and make into what they want. There must be something there that is basically sound and right, or no amount of work on their part will ever envolve a worth while engineer. When some one tells me something like the following, I feel all right about it: "Well, when we got him he didn't know anything, and he wasn't any good, but after I worked on him for awhile he caught on and turned out to be a good man."

I am not in a position to blame these engineers very much for I held exactly the same opinion at one time. Once I thought I could certainly teach young men engineering as it should be taught.

Needless to say, that was before I had ever tried it. I had worked under, over and with engineering graduates from nearly all the well known engineering schools of the country. I had a good first hand look at a lot of them, and I thought that if I ever had the chance I could turn out a better product. That is what almost every engineer thinks who has not tried it.

I once witnessed a very interesting experiment. An able practical engineer—one who had years of experience of a high order—decided he wanted to try teaching for a time. He came to us at the University fresh from several years with a big construction organization. Before starting in, he talked over the work with me and outlined his ideas on teaching. He was going to make his work as practical as possible. He was going to give the students the benefit of his years of high class engineering experience. We decided that he should give an additional course in "Construction Engineering." He thought such a course would give him the opportunity to put over his practical ideas. School opened and he got off to a good start. For about two weeks he seemed very happy and enthusiastic, and when I asked him how his construction course was progressing, he replied "Fine." The third week he did not seem so happy, and about the middle of the fourth week he came to me, evidently worried. "You know that construction course," he said, "Well, I thought when I started it I had enough material to keep going for three years, and do you know I have run out already. What am I going to do about it?" "Of course," he said, "I could go along and tell them a lot of interesting experiences, but I have run out of material of real value." That man was honest and that experience taught him a very valuable lesson. He is a successful engineering teacher to-day.

From what I have said I do not wish to leave the impression that I do not value engineering experience as an aid to high class engineering teaching. Rather, I am convinced that every engineering instructor should have had practical experience in engineering. My point is that there are some things in the engineering world that cannot be taught in the class room. We cannot make the finished product, but we can build a good chassis. The value of engineering experience to an instructor is that he knows better what the finished product must be, and can therefore build better towards that end.

An engineering graduate's success depends on many elements of character and training. You can group them in many different ways, but I am going to refer to them under the general classification of (*a*) Training, (*b*) Personality.

Any attempt at classification is really illogical or impossible, because the different elements and characteristics of a man's make-

up are so interlocked and entwined. One of our many educational blunders has been to consider a man as one would a piece of machinery. Don't try and take him apart and classify him into many distinct and separate parts, each with a definite function. When we realize we can not lay him out on our work bench like so many nuts, bolts, gears and shafts, each with a tag on it, we are not so likely to make some very common mistakes.

Therefore, I am going to talk about the engineering graduate as I know him in more general terms, and I realize that my use of these terms may or may not convey the desired idea. I am also fully aware that what I say is taken from the experience of one man, and that the experience of many men is needed to give any very valuable data.

The biggest thing my experience teaches me with reference to the success of engineering graduates is that *success depends largely on what you might call the man's personality.* This word personality is an indefinite term, but does convey a meaning not better portrayed by any other. I feel that the graduate's success is built around the inside man himself. His character, partly inherited, partly acquired, tells the story. I could give instance after instance where largely because his associates liked him a young man got his "Break."

There are elements of character that build for success in almost any line of work, and these same elements are even more important in engineering. A higher standard is expected from engineers. These elements that make him a good citizen, that make him a good neighbor, that make him respected in his community, and that make a man a man, are fundamental to success in engineering. Of course he has to have first class technical training, that is, his working tool, he has to acquire it by some means or other, but no matter how brilliant he is, or how much natural talent he may have, he will never achieve any great measure of success in life outside of some very narrow specialized field no matter how much genius he possesses unless he also has the human qualities I have mentioned. Many a man of wonderful natural specialized talent with excellent training never gets a real chance to exercise that talent because of other undesirable attributes of character.

We engineering instructors should recognize these facts, and when we talk about courses of study and course material, we should study them both from the standpoint of tool value and character building value. Contrary to what some may contend, I believe that the most technical subject can be taught so as to produce fine values for character development. It is hard for me to believe that a student can associate with all the wonderful ideas and theories developed by science and engineering and not be a better man as

the result of these contacts, provided he has the proper guidance from his instructor.

It seems to me important that engineering students are given the right courses with the right kind and amount of material, but I am here trying to stress the importance of the way these courses are taught. A change in emphasis on the part of the instructor can often change the real character of a course more than the change of material. I feel there has been too much of a tendency to lay the blame for failure in certain cases on the material. About all some engineering teachers seem to thing about when it is evident that desired results are not forthcoming is to change the courses around. I have become painfully bored listening to discussions as to the value of this, that or the other course in the training of engineers where the main theme was as inert as the material discussed. Almost any course can be made alive, vibrant, and a step toward the desired end if the instructor knows what he wants and how to get it.

When I hired a man for an engineering job, I usually looked for a man who had the required amount of technical training to build on, and I then examined him closely to see if he was honest, if he was fair, if he had a sense of responsibility, if he got along well with his associates, and if he had good health. My experience was that if he had those qualifications he made good. Sometimes I made mistakes, of course.

Able men have defined engineering for us in a general way, and we have liked and admired their definitions because they were general definitions and could therefore not conflict with our own ideas. But is there something peculiar to engineering alone that you can set out as distinctive when considering the man rather than the profession? I think there is, but I can't define it. There is an indefinable something in a man that makes you say, "That fellow is a real engineer." You may not be able to catalog it very well, or segregate it, but still it is there and we recognize it. Some have it, some do not. You may call it an engineering attitude, or a way of doing things, or a method of attack, or power, but whatever you may call it, it is highly important that it be cultivated and developed in our engineering students.

From my practical engineering experience I know pretty well what I want in a graduate. I want first of all a man with character, and then I want him to have the proper kind of training in technical engineering that has cultivated his latent engineering instincts or talents so he does things in "an engineering way." I know what I want in the graduate. I have an end in view when I am teaching,

but from experience I also know how hard it is to produce it. All we teachers can do is to set before us an ideal and strive mightily to approach it. The task is not easy. There is, however, just as much satisfaction, or more, in contributing to the success of an individual as in being part of a big successful engineering accomplishment. I have often been asked, "Which do you like better—teaching or practicing engineering"? I like teaching better in some respects, but it was a long time before I could develop the proper respect for the teaching work. You could not stand off and look at your work and say "I did this or that" like you can in practice. But the longer you teach engineering students the more respect you have for your job, and the more worth while it seems. You realize you have a most difficult and interesting job on your hands that is worthy of the best efforts of any man. After all it is a finer and more intricate task to build a man than it is to build a structure or a machine.

Plans for the Spring Meeting of the **Ohio Section**, S. P. E. E., are as follows:

Place of Meeting, University of Toledo, Toledo, O.
Time of Meeting, Saturday, May 6, 1933.

Program:

10:00–10:30 A.M. Opening of Session.
10:30–11:30. Address: The Shifting Emphasis in Engineering Education. W. E. Wickenden, Case School of Applied Science.
11:30–12:00. Discussion.
1:30–2:30 P.M. Address: What Does Industry Expect from Technical Education in the Next Decade? George Hirshfeld, Detroit Edison Co.
2:30–3:00. Discussion.
3:00–3:30. Business and adjournment.

The program has been centered about these two outstanding speakers with the thought that they can contribute much to the crystallization of our ideas and ideals in these critical times.

An invitation is extended to all members of the S. P. E. E., with a special invitation to the members of the Society residing in Michigan, due to their proximity to Toledo. Please reserve Saturday, May 6, for our meeting.

J. B. BRANDEBERRY,
Chairman, Ohio Section, S. P. E. E.

COLLEGE NOTES

University of Detroit.—Dean Clement J. Freund, of the College of Engineering, announces the appointment of Mr. C. C. Johnston as acting director of the civil engineering department to replace the late Professor D. P. Gilmore who died on January 13, 1933.

Mr. Johnston first joined the civil engineering department as an instructor in 1927, advancing to assistant professor and his recent appointment. His degree of B. of C.E. was obtained from the University of Detroit in 1923. His secondary education was obtained at a Fort Wayne, Indiana, high school. Prior to coming to the University, Mr. Johnston had been employed with the Gabriel Steel Company as a designer of reinforcing steel. He has also been employed with the Carey Company of Detroit as an estimator and the S. F. Bowser Company of Fort Wayne, Indiana, as a draftsman.

The co-operative plan of engineering education received official recognition from the Civil Service Commission of the City of Detroit when the Department of Street Railways was placed on a civil service basis in January, 1933. In setting up standards or classifications for jobs to be performed and the personnel qualifications required, the Commission recognized the eligibility of co-operative and part-time engineering students by designating a classification of "Junior Student Engineers." The broad classification of qualifications are that candidates must be:—(*a*) bona fide junior or senior students in an engineering college of a Michigan university of recognized standing; (*b*) on part-time employment; (*c*) under supervision and instructions as part of a training period. Such student engineers are available for employment in the various phases of engineering work in the field, office, shop or laboratory and will perform related work as required. Details have been worked out as to the specific jobs in each department that are available for part-time student work. Minimum entrance qualifications have also been set up and tests are being devised to measure these qualifications on a competetive basis. Scholastic standards are set up, including a minimum of 70 hours of credit. It is expected that the candidates will have had some practical experience in some phase of engineering work, will have some ability to do minor drafting, some skill in the use of tools, ability to prepare and keep simple records, good powers of observation, some

tact in dealing with others, and the characteristics of initiative, industry, and willingness to learn, besides superior general intelligence and mechanical aptitude. The age limit ranges from 18 to 25 years. A similar classification has also been set up for graduate engineers in training with an age limit from 20 to 27 years.

As far as the immediate future is concerned, this new classification will not create jobs for co-operative engineering students at the University of Detroit, nor for summer work for the academic colleges in Michigan. It means, rather, that all impediments to such employment in the future have been removed and that the machinery has been set up for the employment of such students when conditions warrant it.

Massachusetts Institute of Technology.—Under the direction of Professor Kenneth C. Reynolds, a study of the effect of the tides of the Atlantic Ocean on the Cape Cod Canal is being made in the Technology River Hydraulic Laboratory. The object of this study is to determine the effect of the proposed lock which it is hoped will overcome the difficulties navigation encounters in the canal due to the swift tidal currents.

At the present time the canal is a one-way affair 100 feet wide, 25 feet deep, and some 7½ miles long between Cape Cod Bay and Buzzards Bay. The average rise and fall of tide in Cape Cod Bay is five feet greater than in Buzzards Bay, to which is added a three hour difference of tide time. These factors combine to produce a maximum difference of nine feet under such extraordinary conditions as flood tide with a high wind. The resulting swift currents in the canal make navigation difficult and cause delays.

It is now proposed to widen the canal to 250 feet, deepen it to 30 feet, and control the currents by means of a lock. Professor Reynolds is studying the operation of the proposed canal by means of a model over 40 feet long, so constructed that he can accurately reproduce the tidal conditions.

On March 29th leaders of science plan to tender Dr. Elihu Thomson, the General Electric Company's talented engineer and inventor, a dinner on the occasion of his 80th birthday. Dr. Thomson was acting president of the Institute from 1920 to 1922 following the death of President MacLaurin and he is also a life member of the Technology Corporation. At the head of the Committee in charge of arrangements is Professor Dugald C. Jackson, of the Department of Electrical Engineering.

As a result of his contributions to textile research Professor Edward R. Schwartz of the Department of Mechanical Engineering has been elected to a fellowship in the British Textile Institute. In awarding this distinction the British Institute made particular men-

tion of Professor Schwartz's work on the microanalysis of yarn structure. In co-operation with the Textile Laboratory the Department of Biology is studying the effect of bacteria on textile fibers, the Department of Physics is contributing to the technique of color measurements and to fiber analyses by means of X-rays, while the Department of Chemistry is making researches in dye structure and the application of polarized light.

The Pennsylvania State College.—"Penn State" began its economy program more than a year ago by reducing all budgets to a reasonable minimum for efficient teaching.

Small classes will be omitted next year. The curricula in Flour Mill Engineering and Railway Mechanical Engineering have been suspended for a time. Research and extension have been reduced.

"Honors courses," not under that name, have been continued for selected seniors of exceptional ability. Investigations are carried on in the seminar manner under student "steam."

The courses are open to qualified undergraduates and are of an advanced character commensurate with graduate credit toward an advanced degree. It has served to develop initiative and at the same time has served as a selective process by which to choose those of the research type who were especially fitted for further graduate study.

Rensselaer Polytechnic Institute.—In spite of the depression the Board of Trustees have proceeded with the plans for the development of the Institute which have been under consideration for several years.

Although, as in other institutions, there has been a slight decrease in the number of students in some of the enginering courses, the number of applications for admission to other courses, particularly courses in Aeronautical, Metallurgical, and Industrial Engineering, has shown an unexpected increase. To meet the demands which will evidently be made upon it in the immediate future, the Board of Trustees have therefore decided to extend the facilities of the Institute in these fields. In Aeronautical Engineering the basic equipment now available will be supplemented by apparatus representing the latest advances in design and construction. The Metallurgical Laboratories, which have kept pace with the growth of the Institute, will also be reorganized and expanded to anticipate the changes in industry that are likely to occur in the next decade. Although no drastic alterations will be undertaken in the laboratories used in the course in Industrial Engineering, added provision will be made for advanced study in production engineering and allied fields. To carry out these proposals the Board of

Trustees have appropriated $300,000 for any building operations that may be required. Appropriations for equipment will be made as needed.

Like its undergraduate work, the graduate work of the Institute both in instruction and research has undergone considerable expansion. The new bulletin on graduate departments recently issued lists the names of approximately fifty members of the faculty who are offering graduate courses and approximately 150 courses, extending over a three-year period.

Dr. William Lispenard Robb, Head of the Department of Electrical Engineering and Physics, died on January 26th. A member of the faculty for thirty years, he was responsible for the organization and development of the course in Electrical Engineering. Owing to the fact that he surrounded himself with especially able men, the work of the Department has proceeded without interruption. Dr. Matthew A. Hunter, Professor of Electrochemistry, succeeds him as head. Professor Hunter, who was educated at the University of London and in Germany and France, came to the Institute from the Research Laboratory of the General Electric Company. Professor Wynant J. Williams, Associate Professor of Electrical Engineering, becomes Professor of Electrical Engineering for Communication. A graduate of the Institute, he has likewise studied in Great Britain and Germany. Dr. Frederick M. Sebast, also a graduate of the Institute, and Associate Professor of Electrical Engineering, has been appointed Professor of Electrical Engineering for Power. Professor Stanley B. Wiltse, Assistant Professor of Electrical Engineering, has been advanced to the rank of Associate Professor. All the appointees have had numerous contacts with industry and have established their reputations as successful teachers.